CHAPTER 5

PLUMBING FIXTURES AND PLUMBING REPAIRS

LEARNING OBJECTIVE: *Identify different plumbing fixtures; recognize procedures for rough-in measurements and methods of identifying problems; explain repair, maintenance, and troubleshooting of plumbing fixtures and accessories.*

"Roughing-in," as applied to plumbing and pipe fitting, is a term used for the installation of concealed piping and fittings at the time a building is being constructed or remodeled. As the building nears completion, the final connection of the plumbing fixtures is made. Once construction is complete, continuous maintenance and repair will be necessary on the entire water and sewer systems. In this chapter, you will be introduced to various procedures and methods to install, maintain, and repair water and sewage systems. Use the information given here as a foundation on which to build a wider and broader knowledge of the Utilitiesman rating.

PLUMBING FIXTURES

LEARNING OBJECTIVE: *Recognize rough-in measurements and types of fixtures and accessories.*

Plumbing fixtures are the receptacles into which body wastes are placed before being discharged into the sanitary sewer. There are many types and styles of fixtures, some are general, while others have been adapted to meet special applications, such as for hospitals, prisons, and similar institutions. Many plumbing fixtures are constructed solely of vitreous China, iron, or porcelain-covered steel. Always be careful when handling, installing, or repairing fixtures. Military installations usually are planned to house large numbers of personnel, and the plumbing fixtures ordinarily are installed in batteries. The actual installation of a fixture is a hard-and-fast rule; either the manufacturer states how it is to be done or specifications state the so called "roughing-in" measurements of the fixture in question. Sometimes you may have to design and lay out a fixture or battery of fixtures. You must know what water supplies and stack sizes are needed and work these into your design.

Standard plumbing fixtures are individually tested and the amount of liquid waste that can be discharged through their outlet orifices in a given interval is measured. When we learned that the washbasin, one of the smaller fixtures, discharges 1 cubic foot of water per minute, we had the basis for the fixture unit system. One fixture unit of a known liquid discharges 1 cubic meter of water per minute or about 7 l/2 gallons. Even though 7 l/2 gallons is not shown in table 5-1, we chose that value to come up with an even meter. Try this one. How many flushings of a urinal equal five flushings of a water closet or toilet? Five or six? The fixture unit value for different plumbing fixtures is shown in table 5-1.

Each fixture is equipped, of course, with a waste pipe of sufficient capacity to carry off 'quickly and quietly all water supplied to it. A plumbing fixture must also be furnished with water at a rate of flow that will fill it within a reasonable time.

Table 5-1.—Plumbing Fixture Unit Values

Fixture	Units
Lavatory or washbasin	1
Kitchen sink	2
Bathtub	2
Laundry tub	2
Combination fixture	3
Urinal	5
Shower bath	2
Floor drain	1
Slop sink	3
Water closet	6
180 square feet of roof drained	1

Table 5-2.—Minimum Size Fixture Supply

Fixture	Supply Pipe diameter min. size
Water closet (tank type)	1/2
Water closet	1
Flushometer urinal with flushing valve	3/4
Laundry tubs	1/2
Kitchen sink	1/2
Lavatory	1/2
Slop sink	1/2
Drinking fountain	1/2
Shower	1/2

As per the *National Standard Plumbing Code,* table 5-2 shows the minimum supply pipe diameters.

ROUGH-IN MEASUREMENTS

Figures 5-1 through 5-6 show single-line drawings of general rough-in measurements for various fixtures. The figures show general measurements and will vary depending on type of fixture and manufacturer. It is your responsibility to identify the fixtures you will be using, so you can obtain the proper rough-in measurements.

Service connections for steam radiators depend upon the sizes to be installed and location of each. The same holds true for water tanks used for storing or heating.

After roughing-in, you can easily install the plumbing fixtures and trim work. Instructions are given here for the installation of various fixtures and accessories. We cannot include every type of fixture you will install; but if you learn to install the fixtures covered in figures 5-1 through 5-6, you should not have any problems with other types.

WATER CLOSETS

Water closets come in various shapes, designs, and colors. The device is designed to receive human waste and dispose of the waste properly in a sanitary sewer system. Most water closets mount on the floor, but there are models that are wall hung. Modem water closets have various design features which create different flushing actions. To read more on the various designs and flushing action principles, see the publication titled *Plumbing Installation and Design* by L. V. Ripka.

Installation

To install a water closet (fig. 5-7), follow these procedures as a general guide.

1. Slip the water closet flange over the closet bend and slide it down until it is level with the finish floor.

2. Prepare the joint for a lead-caulked joint; pour and caulk the water closet flange to the closet bend.

3. With hammer and cold chisel, break off the portion of the closet bend that projects above the water closet flange. Do not break the closet bend below the flange.

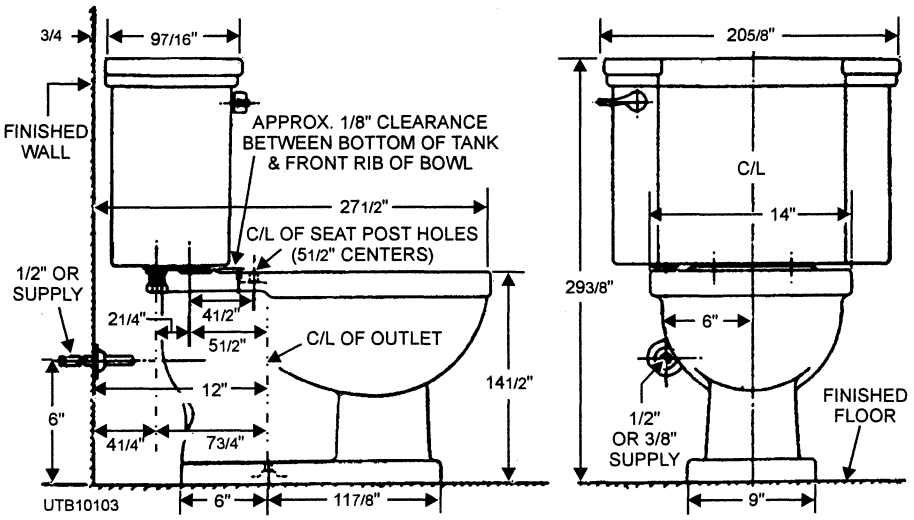


Figure 5-1.—Tank-type water closet.

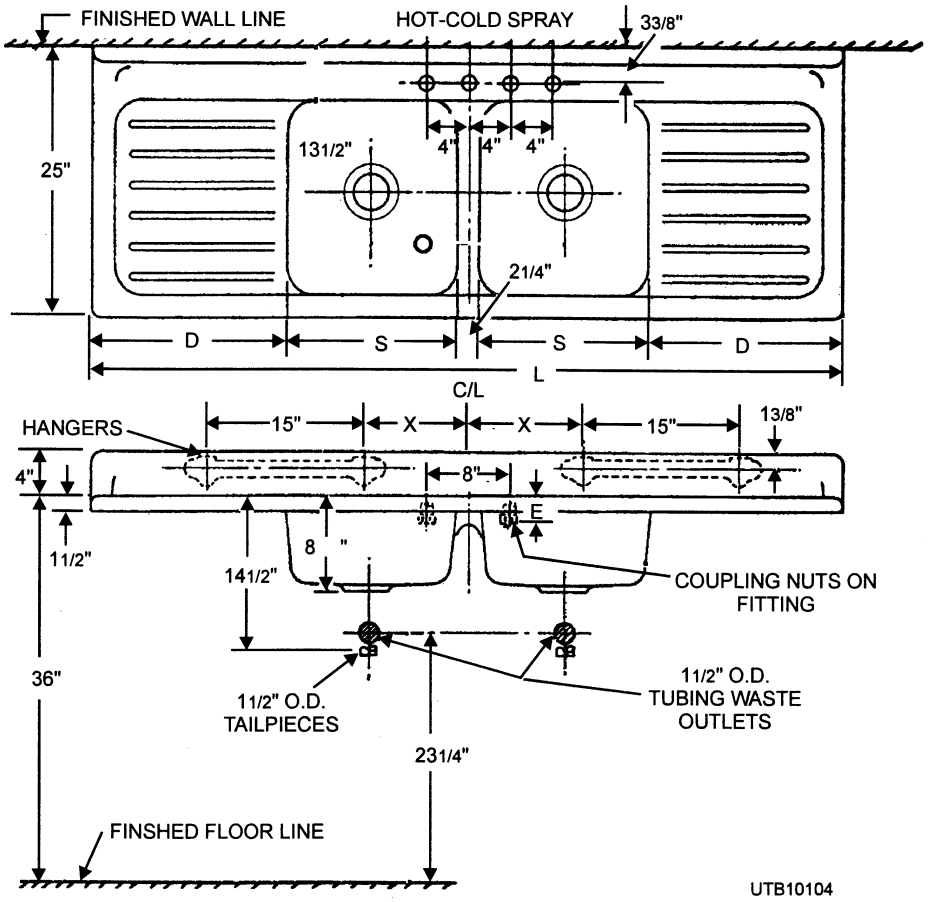


Figure 5-2.—Sink.

4. Place the two brass closet hold-down bolt heads in the slots of the flange.

5. On the bottom of the water closet, as shown in view A, figure 5-8, slip the preformed sealing ring over the horn to form a sealing gasket for the water closet against the face of the flange. Do not use putty as it will dry out and leave a possible sewer gas leak.

6. Turn the water closet bowl right side up and set it on the flange with the horn projecting down into the flange. In setting the bowl on the flange, as shown in view B, figure 5-8, guide the two hold-down bolts up through the bolt holes on either side of the base of the water closet. Using your full weight, press down and twist slightly to settle the bowl and the wax ring into position. The bowl should be perfectly level when settled. Check for level. If off level, use a wedge.

7. Install nuts on the hold-down bolts and tighten them alternately. Do not overtighten them as this may crack the base of the water closet.

8. A wall-mounted water closet, as shown in view A, figure 5-9, is attached to the wall by a chair carrier, similar to the one shown in view B, figure 5-9. The chair carrier is positioned and bolted to the floor. The foot carries the weight of the entire closet independent of the walls and drainage connections. A standard fitting is used to connect between the drain and the closet bowl after the chair carrier is bolted down. The fittings are for 4-inch iron, lead, or soil pipe. The bolt holes in the chair carrier are slotted to facilitate installation of the closet bowl.

When mounting a close-coupled tank on a closet bowl, note that two bolts hold the tank on the bowl. Figure 5-10 shows how. The water supply pipe is between the bolts and drops the water directly into the bowl. A specially designed gasket is installed between the tank and bowl to make the connection waterproof. The bolts are tightened from underneath the closet bowl. Do not apply too much pressure when you tighten these bolts, because you may crack the bottom of the tank or the back of the bowl.

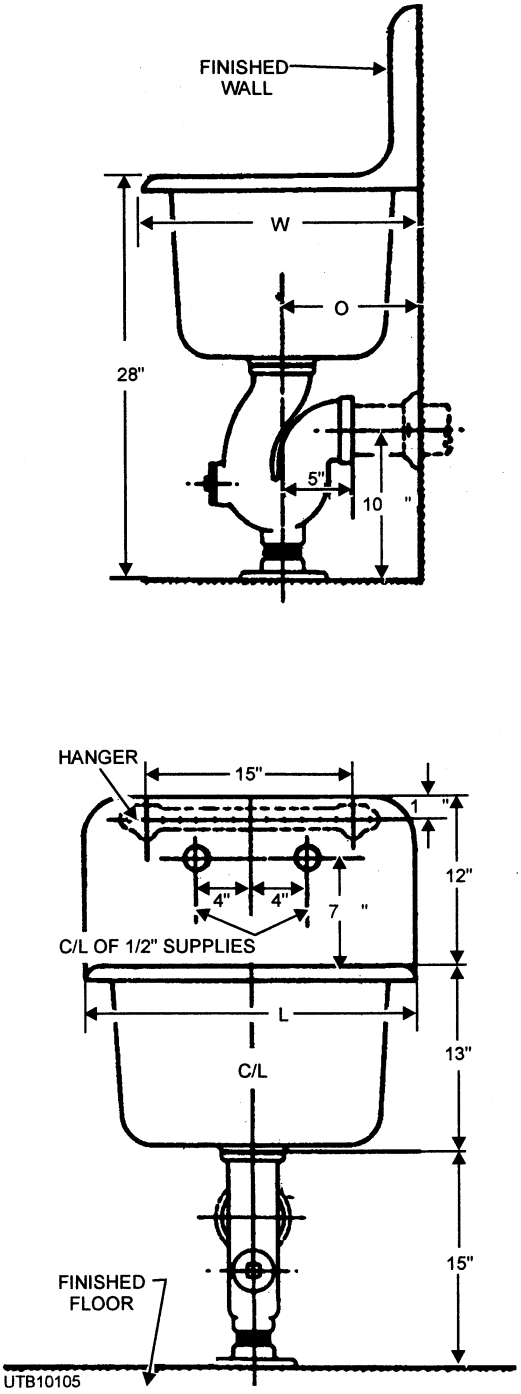


Figure 5-3.—Service sink (slop sink).

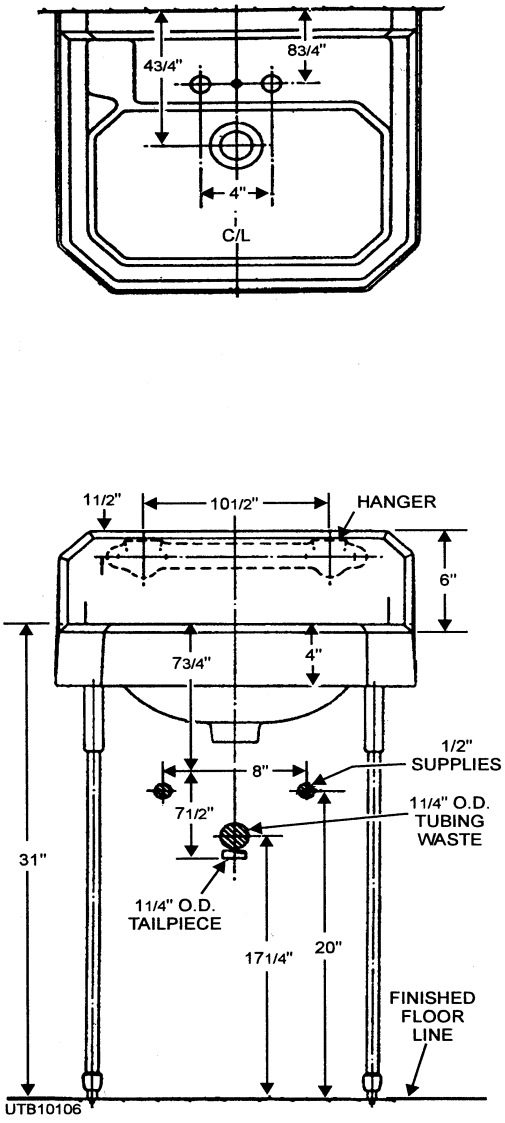


Figure 5-4.—Lavatory.

After the tank is firmly attached to the bowl, connect the water supply pipe to the tank inlet with a riser tube, as shown in figure 5-11. The jiffy connector used here is the same as the connector used to connect the water supply to the faucets of a lavatory.

Flushometer Valves

Flushometer valves are used in place of a tank-type valve in some applications. When a flush valve is used, no tank to hold the flushing mechanism or water is required. Flush valves operate by diaphragm or piston action.

Flush valves require less water volume per flush than a tank-type valve, provide quicker multiple flushing capability, and lower maintenance costs in commercial applications; however, they are noisier than tank-type valves, initially cost more than a tank-type valve, and require a higher operating pressure than tank-type valves. Basically, the flush valve is suited more for the commercial or industrial application, and the flush tank is used in small buildings or single family dwellings.

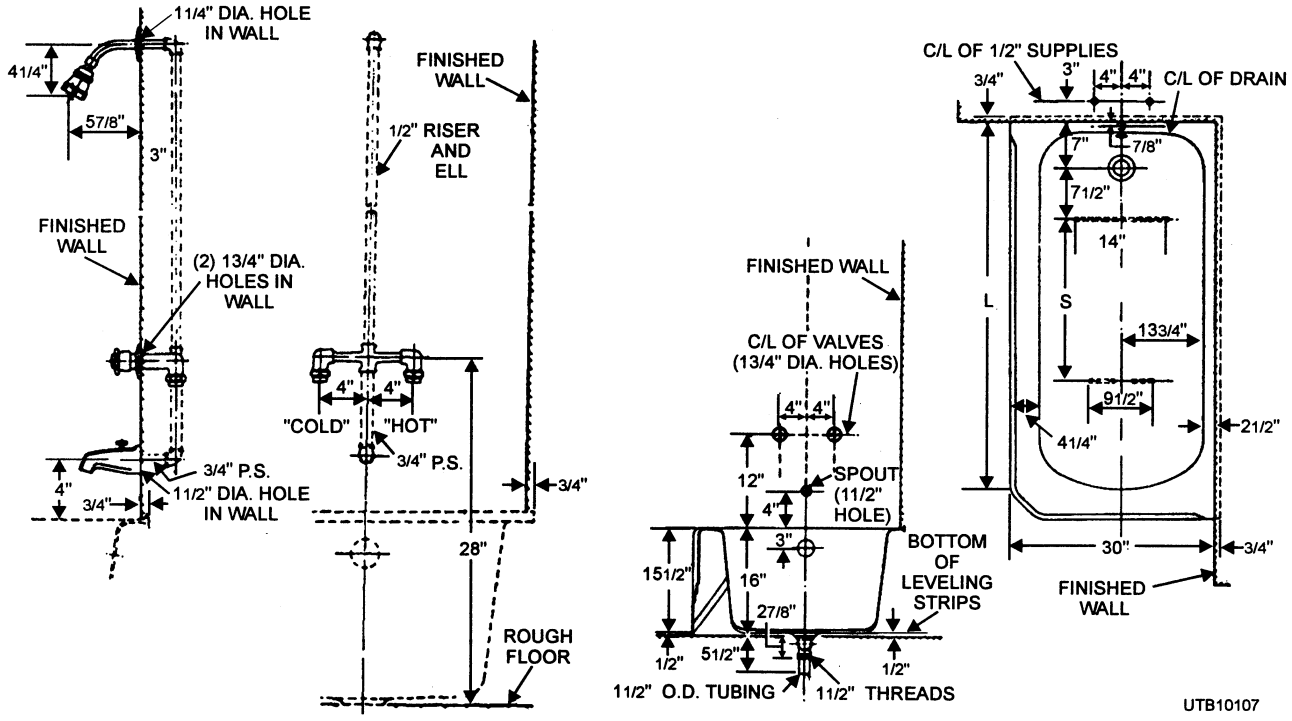


Figure 5-5.—Tub-and-shower combination.

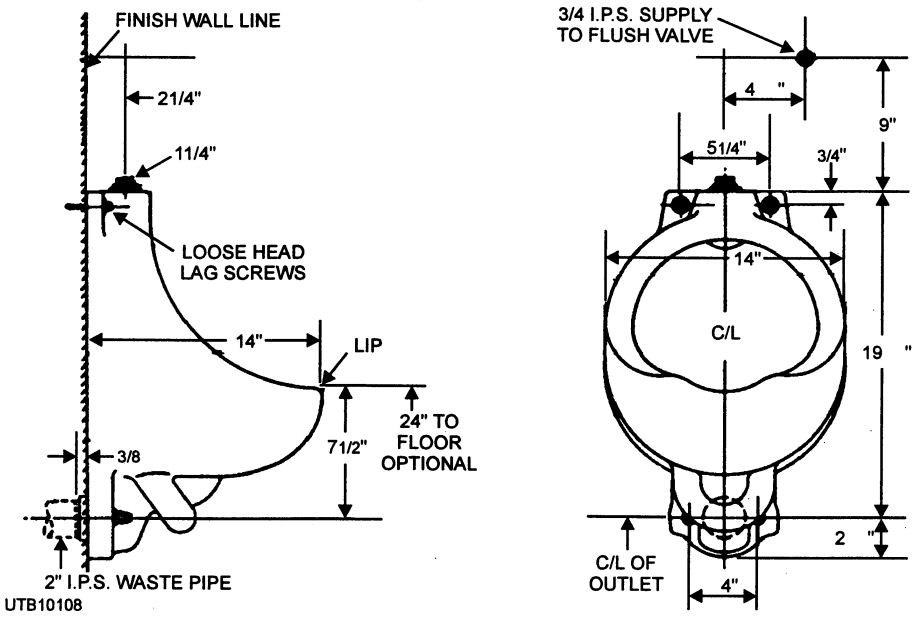


Figure 5-6.—Wall-hung urinal.

A backflow preventer, such as the type shown in figure 5-12, should be installed on the discharge side of a flushometer. A backflow preventer should be installed on the supply line of a float valve in a water closet tank if the tank outlet is below the flood level rim of the closet bowl.

A detail of a diaphragm type of flushing valve is shown in figure 5-13. The diaphragm type of valve consists of an upper and lower chamber. These chambers are separated by the diaphragm and relief valve. The lower chamber is connected directly to the incoming water supply. This incoming water is the flushing water and also the water shuts the valve off after the flushing period. The valve is flushed by the diaphragm and the water pressure in the upper chamber. Water is forced into the upper chamber through a small orifice (hole) in the diaphragm. Water

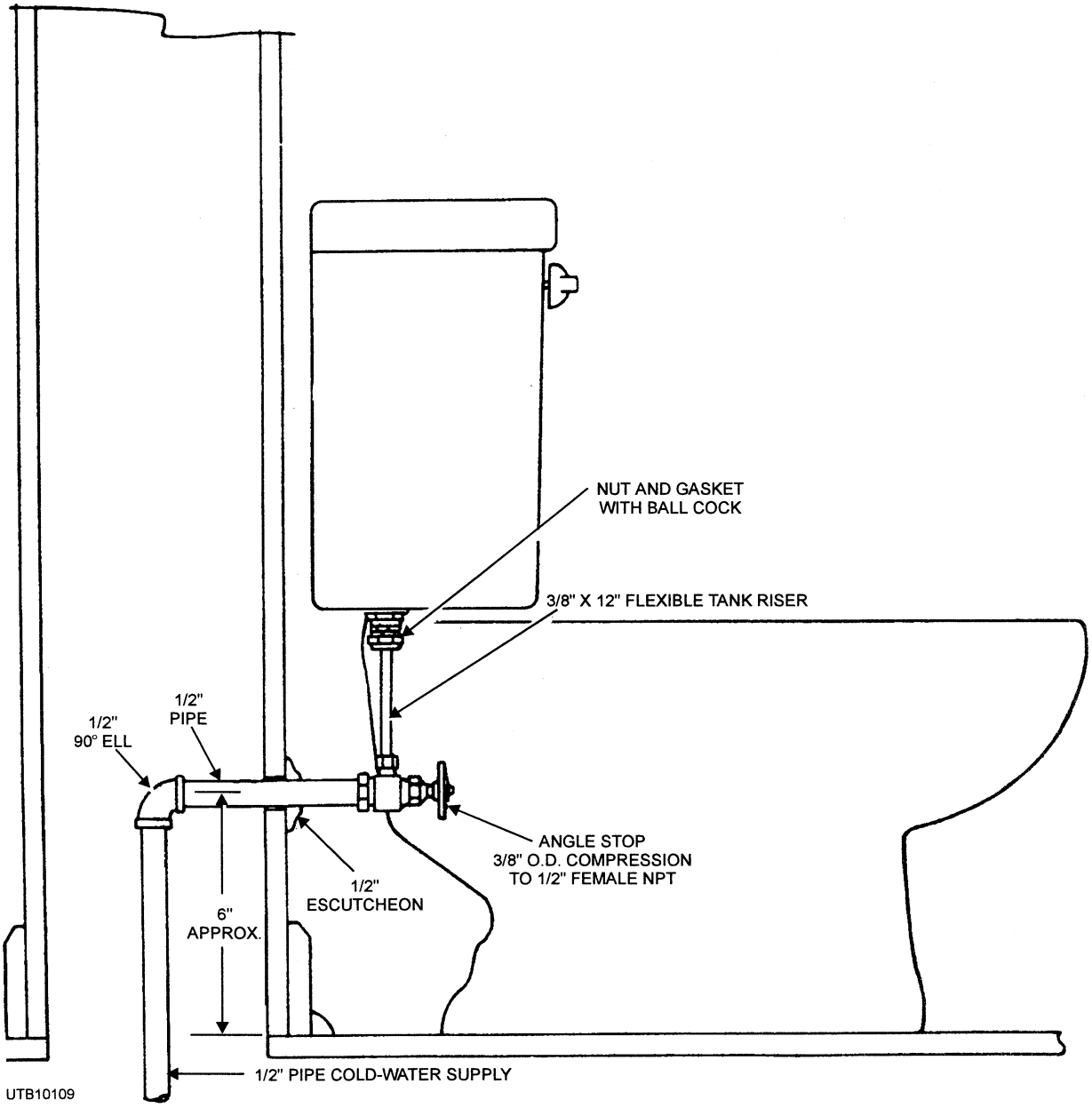


Figure 5-7.—Water closet (tank type).

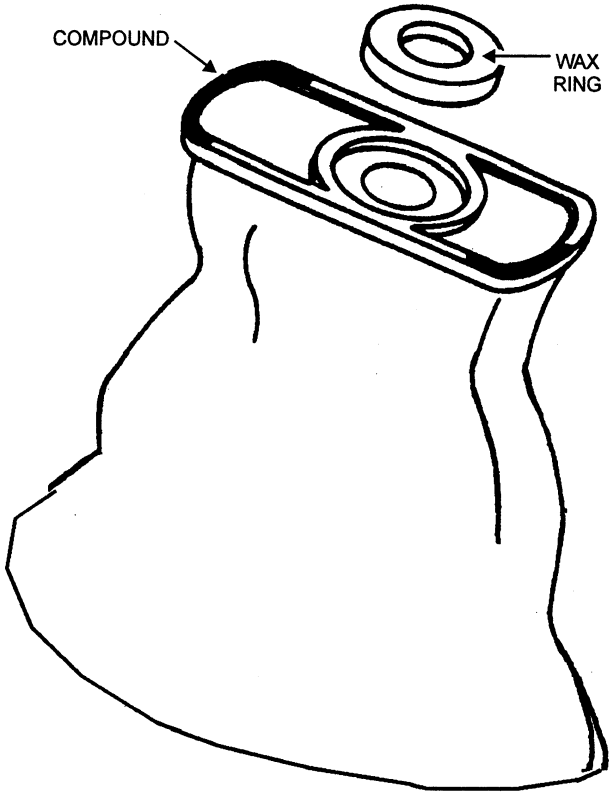
pressure, passing through this orifice into the upper chamber, creates the pressure required to force the diaphragm down and shuts off the flushing water. By moving the flushing handle, the relief valve tilts open. Then pressure decreases in the upper chamber to less than that of the incoming and flushing water. The action allows the flushing water pressure to raise the diaphragm off the flushing seat and recycle.

Figure 5-14 shows a piston type of valve. With this type of flush valve, the piston is drawn up when the flushing begins, then to its closed position by the filling of the upper chamber through the expeller orifice tube.

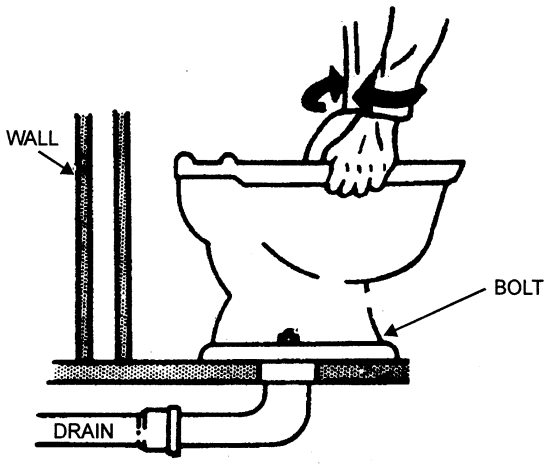
Flush valve assemblies on urinals and water closets may be protected from unnecessary damage and wear by installing a grip handle or guard firmly over the handle housing. This grip handle increases the operating life of flush valves and thereby reduces service calls on the repair of flush valve assemblies and plumbing fixtures.

URINALS

Two major types of urinals in use are the floor-mounted and wall-mounted urinals. With spacing being limited, we will only consider some of the main items relating to installation of the wall-hung urinal



A. INSTALLING A WAX RING GASKET



B. PLACING THE CLOSET BOWL

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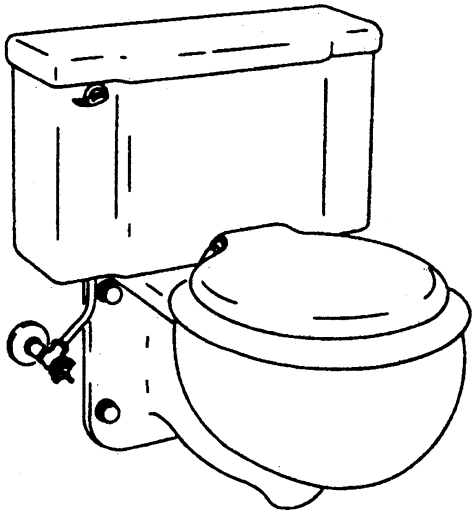
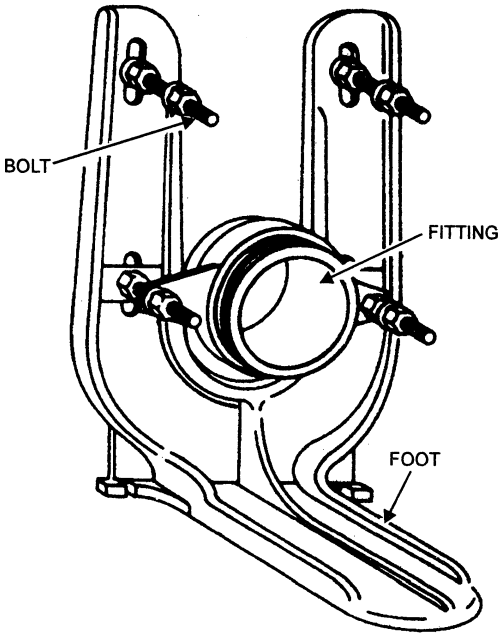
Figure 5-8.—Setting a closet bowl.



A. WALL-MOUNTED WATER CLOSET



B. CHAIR CARRIER FOR A WALL-HUNG WATER CLOSET

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Figure 5-9.—Wall-mounted water closet.

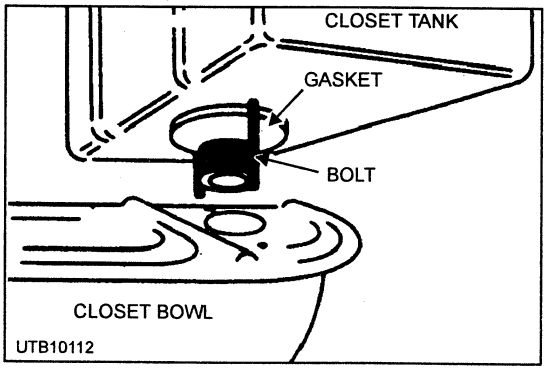


Figure 5-10.—Mounting of a close-coupled tank on a closet bowl.

(fig. 5-15). If you learn to install this type, you should have little trouble installing floor-mounted urinals.

In setting the wall-mounted urinal, see that the rough-in of the waste pipe is at the correct height so after installation the urinal is within reach of the user. The lip of the urinal should be from 20 to 25 inches from the floor. If the rough-in already installed in the building places the height of the urinal above or below these general measurements, the rough-in should be removed and the waste pipe brought in at the proper height. Since the wall-hung urinal sometimes has an

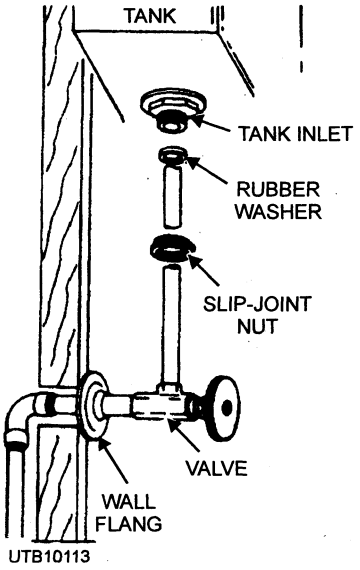


Figure 5-11.—Closet tank water-supply line.

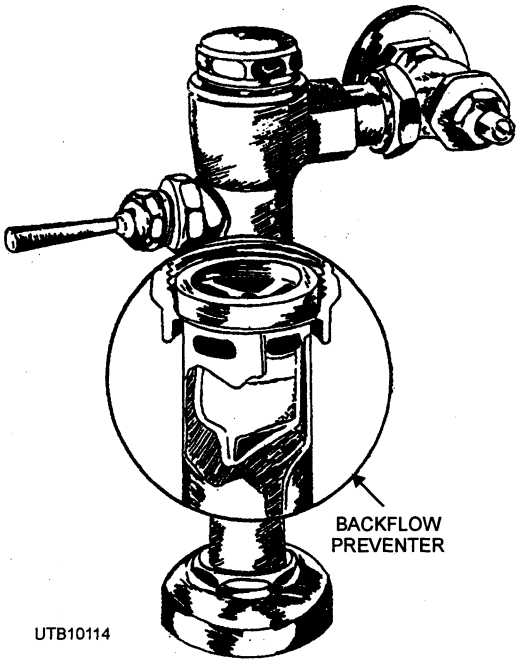


Figure 5-12.—Flushometer valve showing enlarged flow of backflow preventer.

integral trap (trap contained in fixture), it is not always necessary to provide the waste pipe with a separate chrome or iron trap. Integral trap urinals have a back spud fitting that connects the waste pipe and urinal together with a rubber seal in between. Install a mounting board on the wall where a urinal is to hang. This board will provide firm support for the urinal. The last step in the installation of the wall-hung urinal is the connection of a flushing mechanism, such as the diaphragm type of flushing valve.

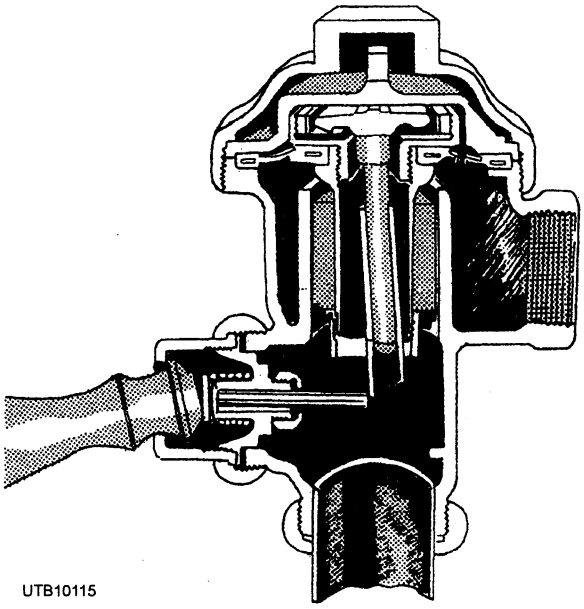


Figure 5-13.—Diaphragm type of flushing valve.

BIDETS

A bidet is equipped with running cold and hot water and is used for bathing external genitals and posterior parts of the body. The bidet is installed mainly overseas; however, the bidet is becoming very popular in the United States.

The water is controlled by faucets the same as a lavatory. The flow of water may rise from the center of the bowl or around the rim. The bowl contains a stopper which holds water in the bowl if desired.

SINKS

Sinks are made in different patterns, each intended to serve specific purposes. Two common types of sinks are the kitchen sink and the service sink (slop sink).

Kitchen Sink

The KITCHEN sink is available in different sizes and may have either a single bowl or a double bowl. It is made of either enameled steel or enameled cast iron.

In the installation of a kitchen sink, it is important that the sink be built into a cabinet or hung from a bracket that is screwed to a mounting board (fig. 5-2). The bracket should be screwed into the mounting board in a position where the sink, when mounted, is at a convenient height for use. As a rule of thumb, the distance between the top of the drainboard and finished floor should not be less than 36 inches.

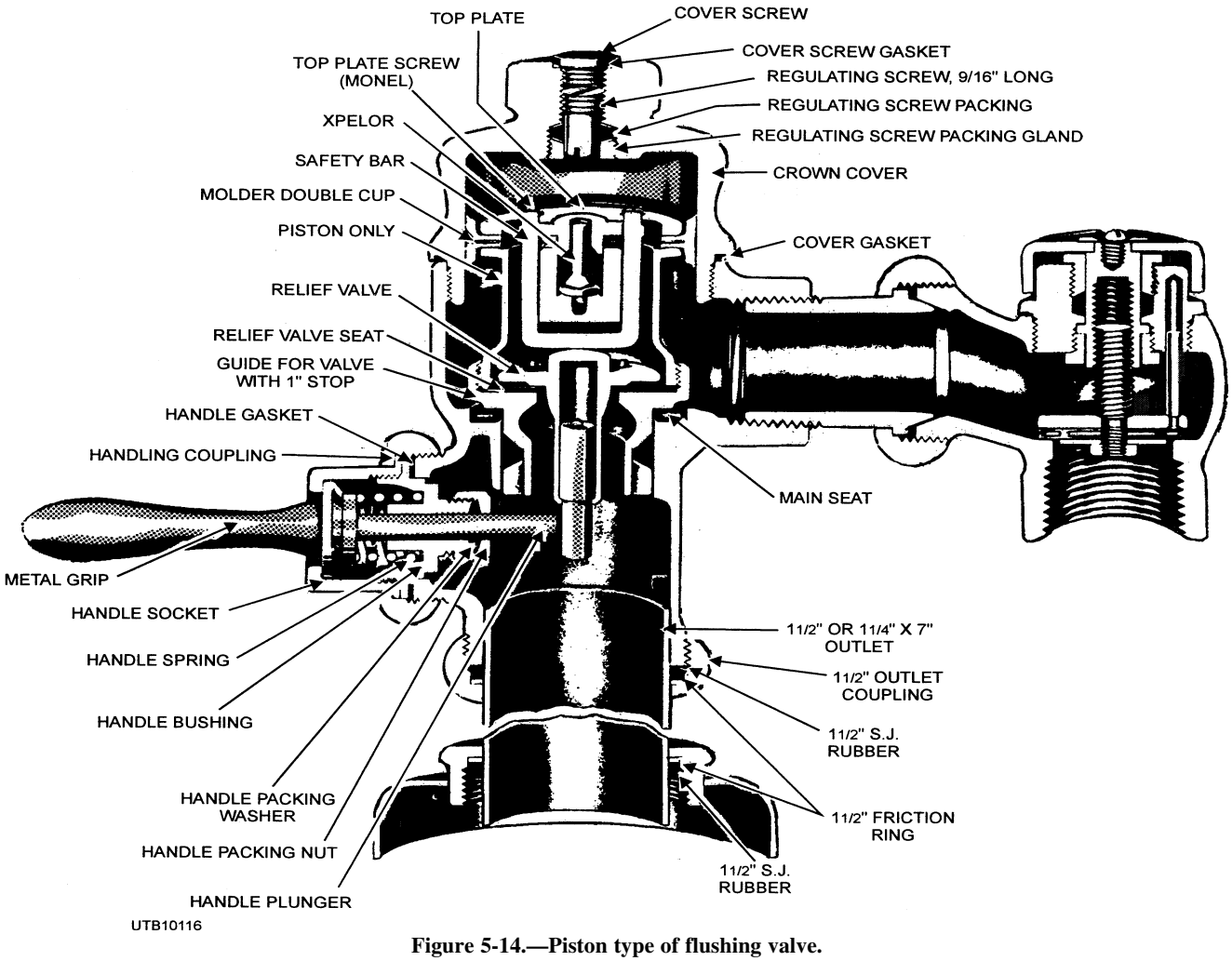


Figure 5-14.—Piston type of flushing valve.

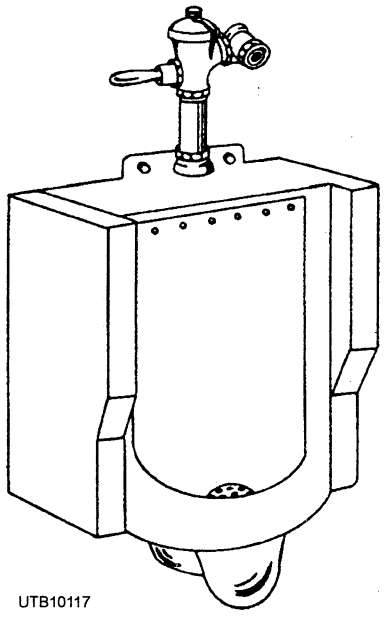


Figure 5-15.—Wall-mounted urinal.

After screwing the bracket into place, lower the sink into position on the bracket, so the lugs, cast into the back of the sink, fit down into the corresponding notches in the bracket. Screw the strainer and tailpiece into the sink bowl and connect the trap to the rough-in waste. To complete the installation, select a suitable faucet. Install the faucet on the sink and connect the water supply to it, as shown in figure 5-16. Then install and connect the waste lines to the sink, as shown in figure 5-17.

Service Sink

A SLOP sink, also referred to as a SERVICE sink, is especially useful for filling a bucket or washing out a swab. It has a deep bowl and generally is constructed of cast iron and finished in enamel.

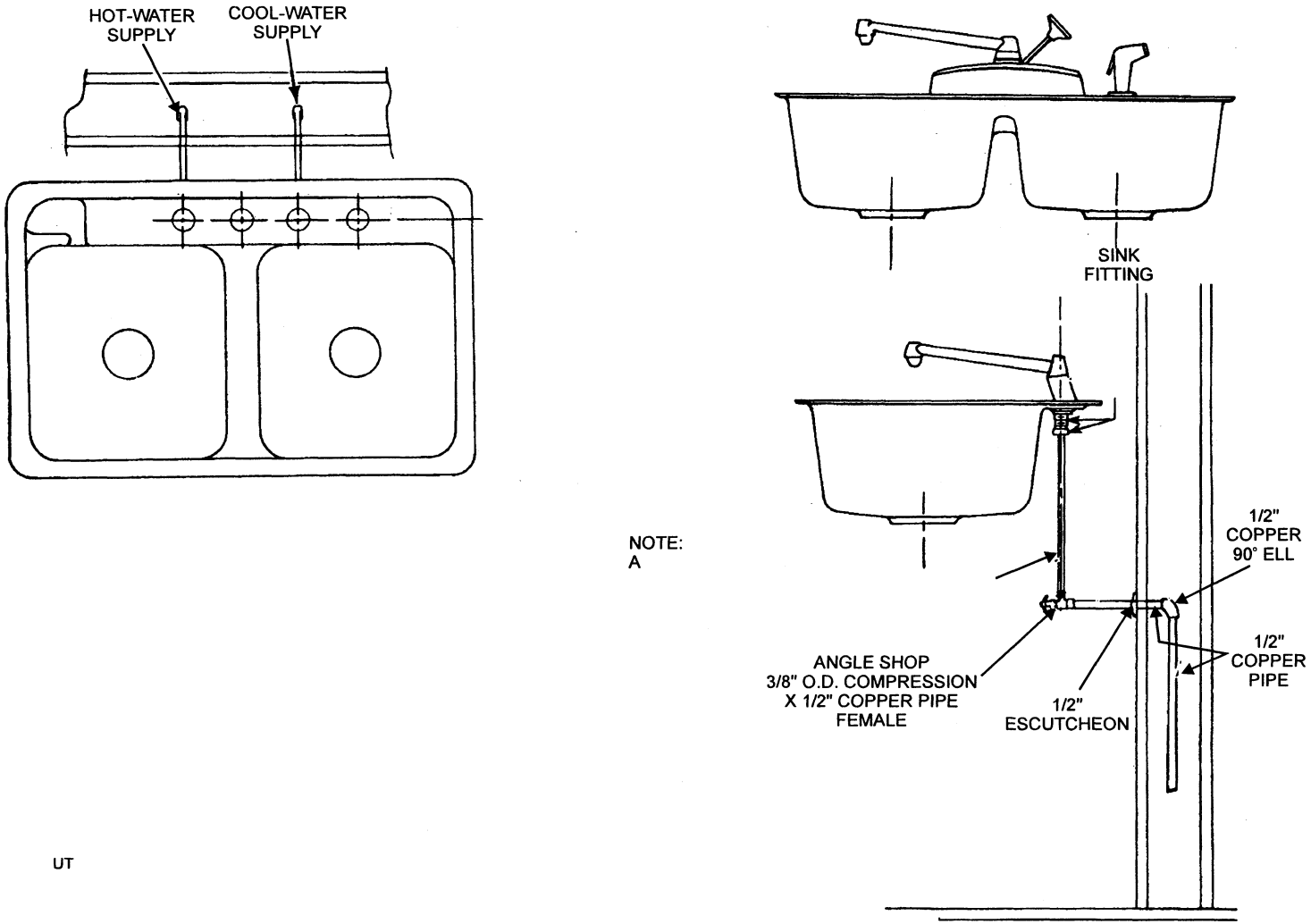


Figure 5-16.—Kitchen sink water-supply hookup.

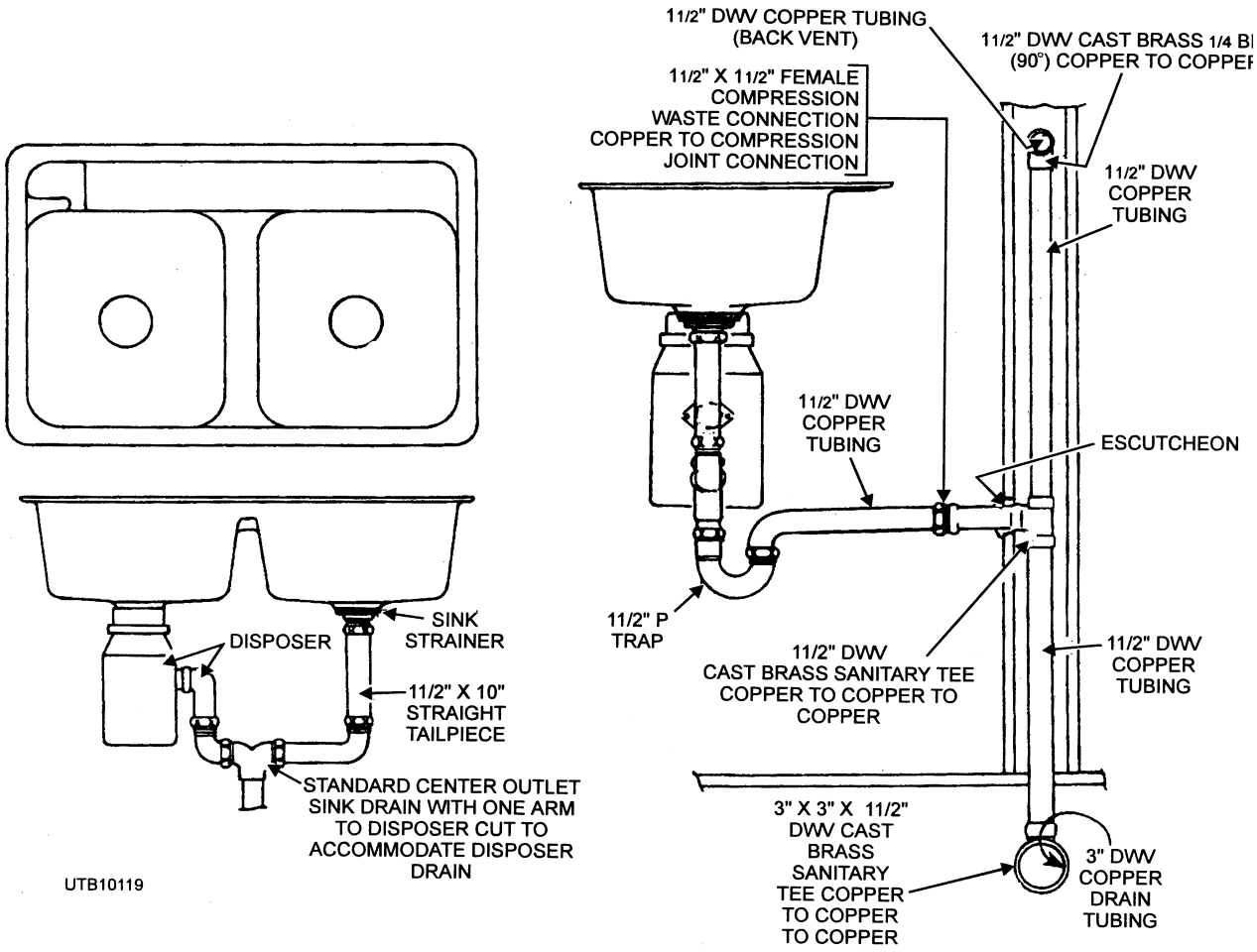


Figure 5-17.—Kitchen sink waste hookup.

The slop sink installation is similar to the kitchen sink installation. The slop sink is also mounted on a bracket and mounting board (fig. 5-3). In addition to the hanger, the slop sink has a built-in adjustable stand trap that bolts to the floor and provides a pedestal support (fig. 5-18). The stand trap should be adjusted to take most of the weight off the hanger and prevent the unit from sagging. After the fixture has been set in place and the waste supply has been connected, suitable faucets are installed and connected to the water supply, and the unit is ready for use.

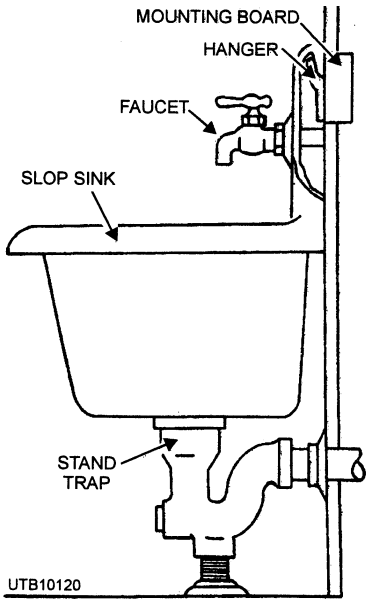


Figure 5-18.—Detail of a service (slop) sink.

Lavatories

The wall-hung lavatory, the most common type in use, is suspended from a bracket screwed to the wall. It may or may not be supported (additionally) by legs. Figure 5-4 shows a view of a wall-hung lavatory. To install this fixture, follow the steps below in the order given.

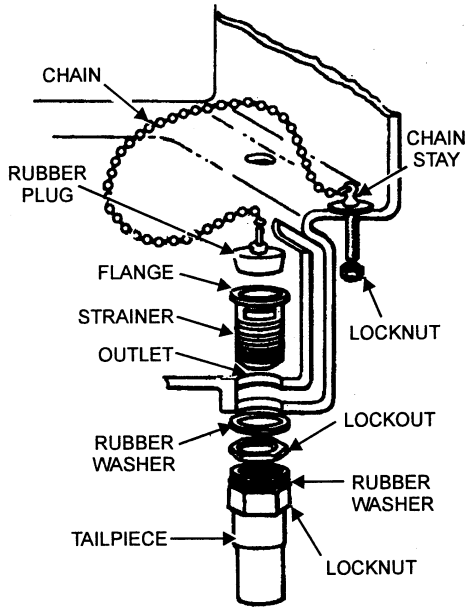
1. Mark the wall at the correct height for a lavatory and secure a hanger to the wall.

2. Position the lavatory on the hanger.

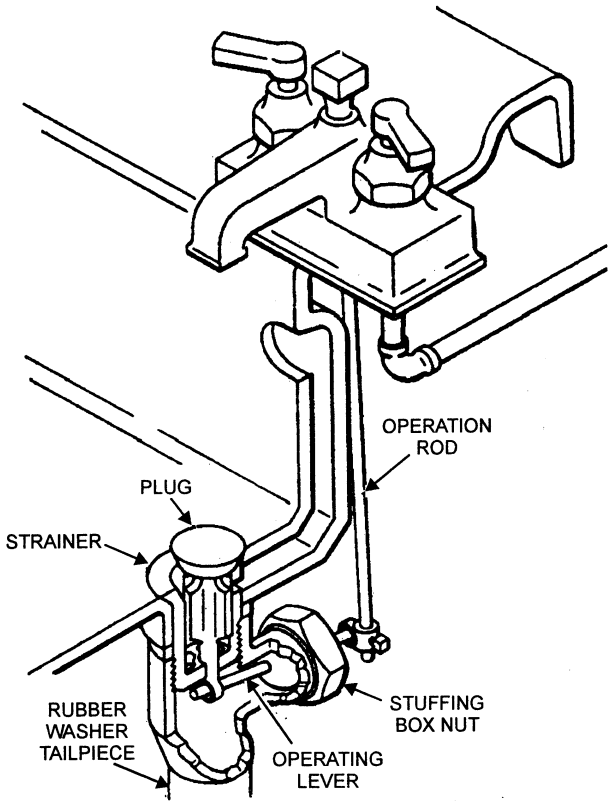
3. Install the lavatory faucets using a basin wrench.

4. Install the permanent opening (P.O.) plug drain, as shown in view A, figure 5-19, or the pop-up type of drain, as shown in view B, figure 5-19.

5. Connect the water-supply lines, as shown in figure 5-20, to the faucets.



A. EXPLODED VIEW OF A P.O. PLUG DRAIN



B. CUTAWAY VIEW OF A COMBINATION LAVATORY FAUCET AND POP-UP DRAIN

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Figure 5-19.—Lavatory drains.

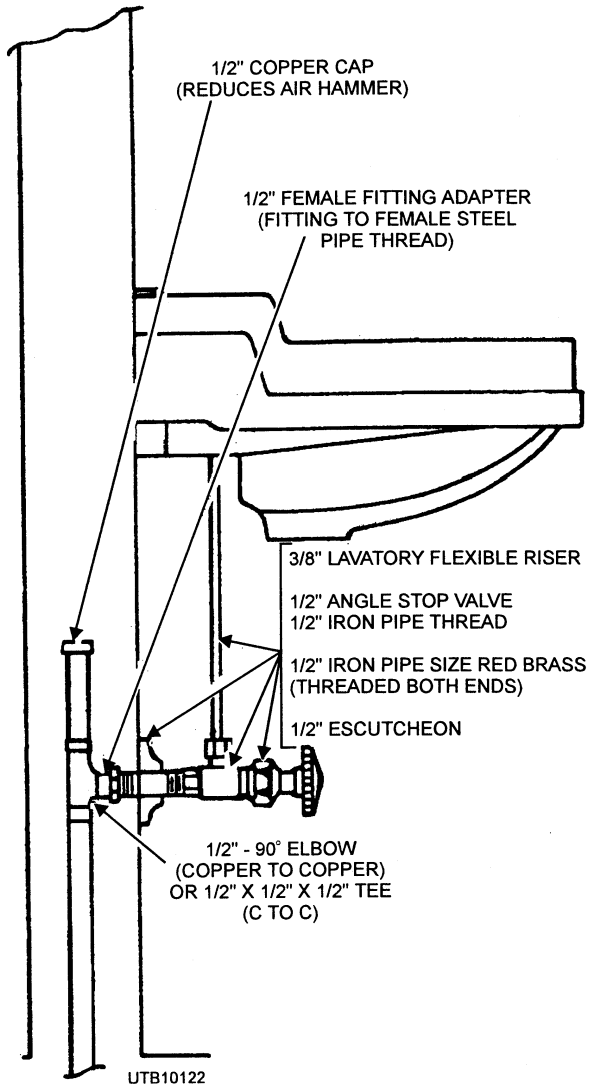


Figure 5-20.—Lavatory water-supply-lines hookup.

6. Connect the waste-supply lines, as shown in figure 5-21, to the lavatory.

Faucets

As a Utilitiesman, you may often be called upon to install or make repairs to faucets. There are many types of faucets in general use, such as the bib, lavatory, bath, and kitchen combinations.

The hose bib faucet, as shown in view A, figure 5-22, is used where outside hose connections are needed.

You probably recognize the combination faucets, as shown in views B, C, and D of the figure. This faucet generally is used to combine the flow from hot-and-cold water pipes. A main feature of these faucets enables the water to be tempered as it is discharged

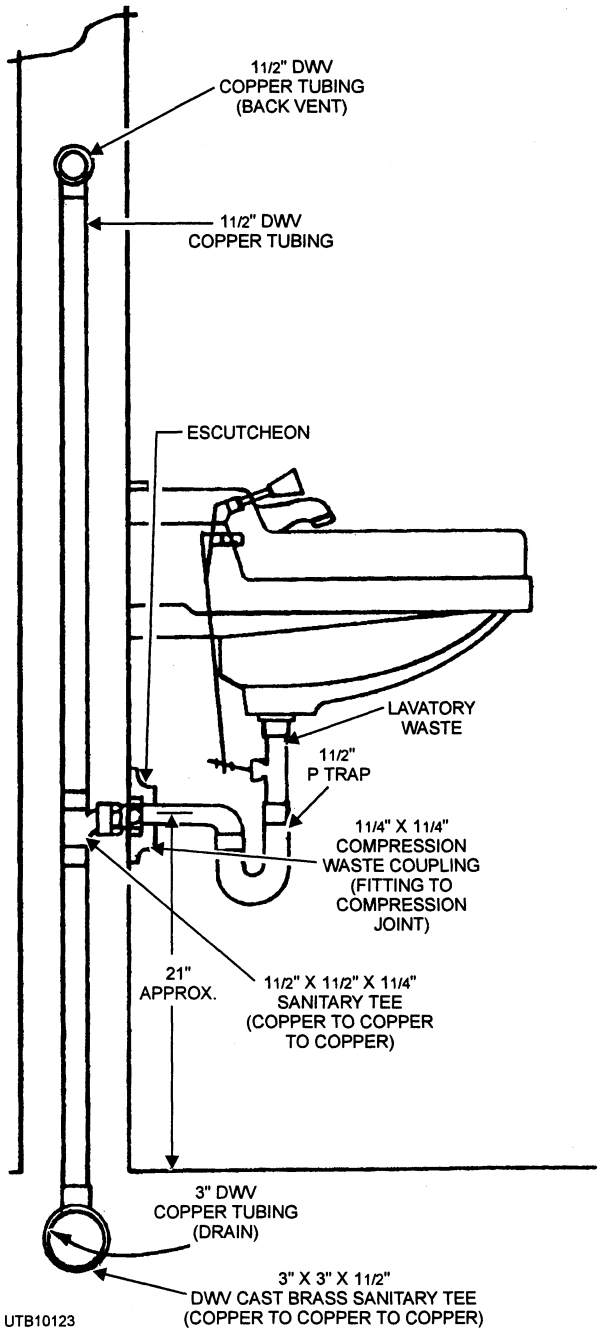


Figure 5-21.—Lavatory waste hookup.

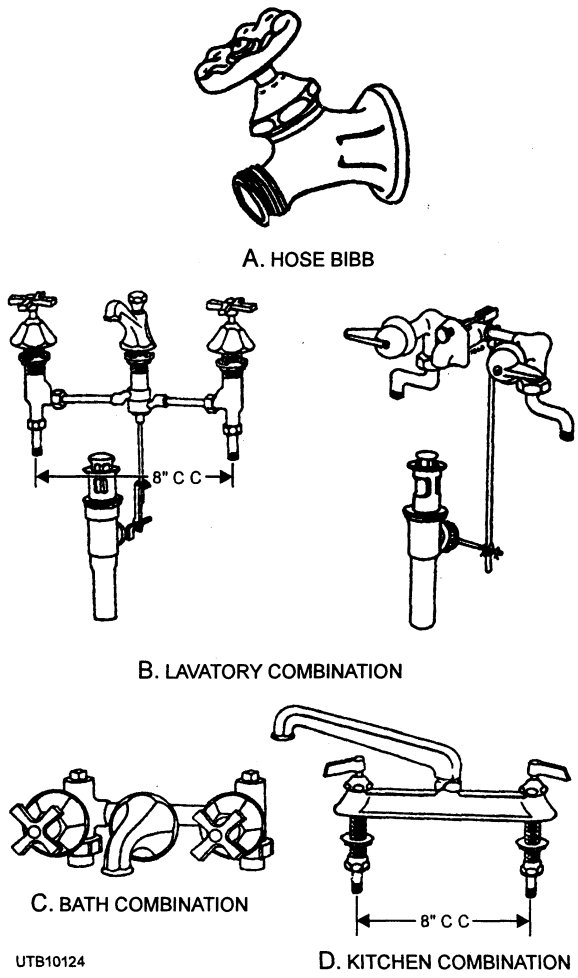


Figure 5-22.—Types of faucets.

through a single spout. They are commonly used on lavatories, baths, or kitchens.

SHOWER-AND-TUB COMBINATION

Several types of bathtubs are on the market today. Some of them are the recessed, the corner recessed, the sunken, and the leg type. Most tubs are made in several sizes, ranging from 4 to 6 feet in length and are designed as right- or left-hand tubs, depending on the location of the drain. When you face the tub, if the drain is on the right end, it is a right-hand tub; if on the left end, a left-hand tub. Most bathtubs today are made of enameled cast iron, enameled pressed steel, or the fiber glass design which is the most commonly used for the built-in type.

The installation of both the bathtub and shower is simple. Tubs and showers come in many different applications: tubs, showers, tub-and-shower combination, and gang showers (large room with no privacy partitions or dividers).

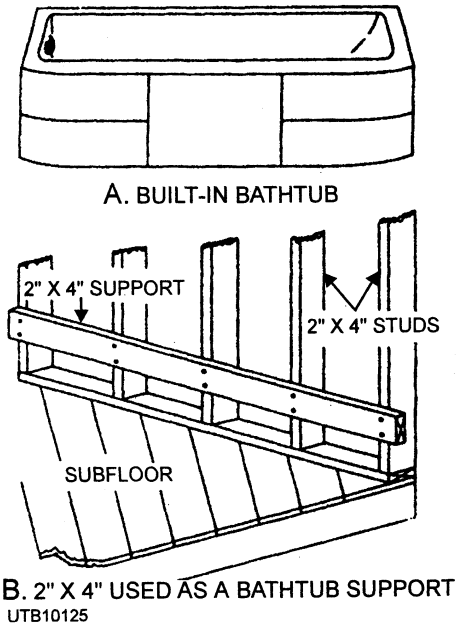


Figure 5-23.—Bathtub and support.

To install a tub, like the type shown in view A, figure 5-23, place the rim of the tub on the 2- by 4-inch support nailed to the 2- by 4-inch studs, as shown in view B, figure 5-23. Check to be sure the tub is level. Once the tub is in place, hook up the water-supply lines, as shown in figure 5-24. Now you have a bathtub and shower combination. Water is furnished by a faucet and spray nozzle. Two valves usually control the flow of water to these units. Ordinarily, when the valves are opened, the water runs into the bathtub from the bathtub faucet. However, for water to run through the shower head, the valves are opened as for filling the bathtub; the diverter which is located in the bathtub faucet must be raised. This combination gives the bather two means of taking a bath.

A tub drain and overflow are usually similar to that shown in figure 5-25. The drain assembly is installed in the space provided by the studs at the end of the tub. The overflow and waste drains are made of chrome. The hidden parts are of rough brass and brass tubing. The fittings are 1 l/2 inches in diameter and come with a pop-up waste or a rubber stopper fastened to the overflow by a chrome chain. This drain and overflow combination is connected to the P trap with slip-joint nuts and rubber washers to seal off the leaks. The drain in the bottom of the tub is sealed against leaks with plumber's putty and rubber rings.

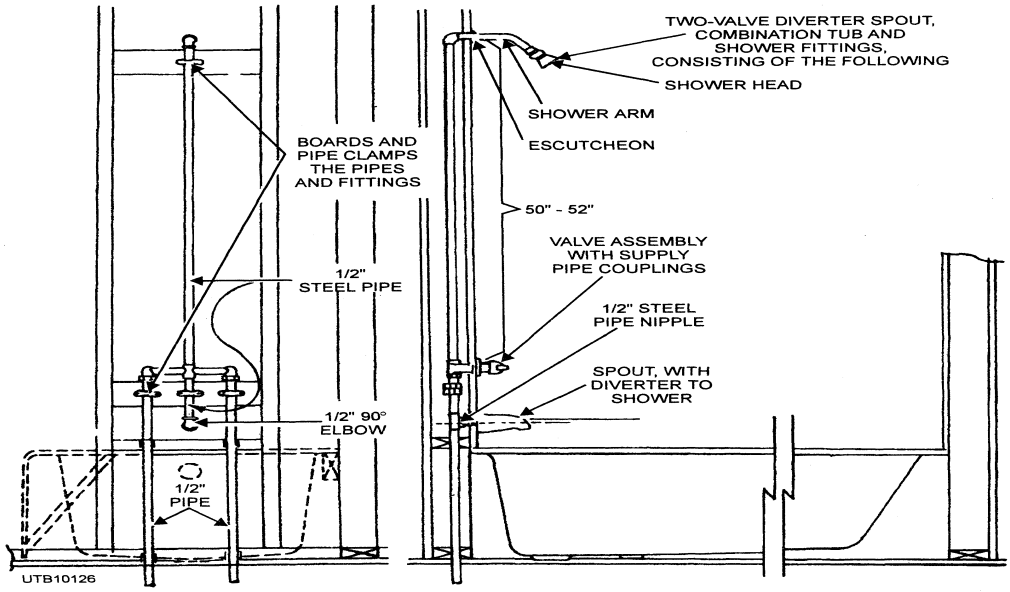


Figure 5-24.—Bathtub and shower piping combination.

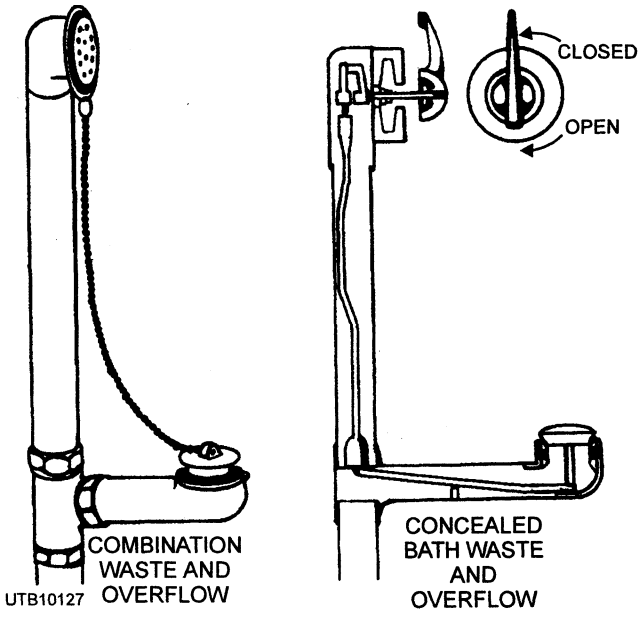


Figure 5-25.—Bathtub combination waste and overflow.

The wastewater supply lines, as shown in figure 5-26, are then connected to the tub.

The faucet and shower combination for a bathtub and shower is connected to the hot and cold waterlines that were installed when the piping was roughed-in. The manufacturer's specifications should be used to determine the height of the riser. The height, however, may be specified by the user. The shower and bathtub piping and fittings installed within the wall are made of rough brass; those that extend through the finished wall have a chrome finish. A typical bathtub and shower piping arrangement is shown in figure 5-27. When you make this type of bathtub and shower installation, be sure to locate the bathtub spout from 2 to 4 inches above the rim of the tub. Spacing the spout above the rim of the tub prevents siphoning of the water from the tub in case the valve is left open and the water drops at the same time. This installation prevents cross-connection between potable and nonpotable water.

The mixing valves in the shower system supply a uniform temperature of water for the shower or tub. The temperature of the water may be regulated between the limits of the temperature of the cold-water supply and the hot-water supply. The equipment used to control the temperature of the water are the manual, the pressure, and the thermostatic mixing valves.

The manually controlled mixing valves consist of two hand-operated valves in one body with an outlet for both valves that feed the shower head. The valves are turned by hand to control the temperature of the water. Manually controlled valves require a piping arrangement similar to the one shown in figure 5-28. This water tempering setup does not protect against

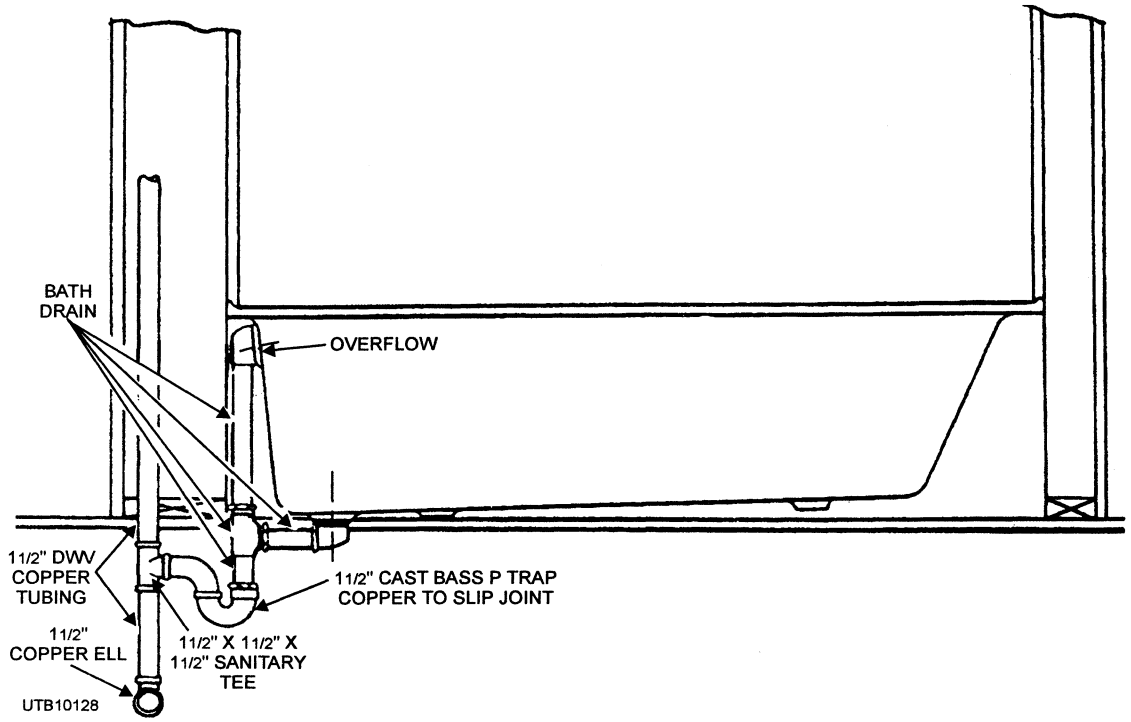


Figure 5-26.—Tub waste hookup.

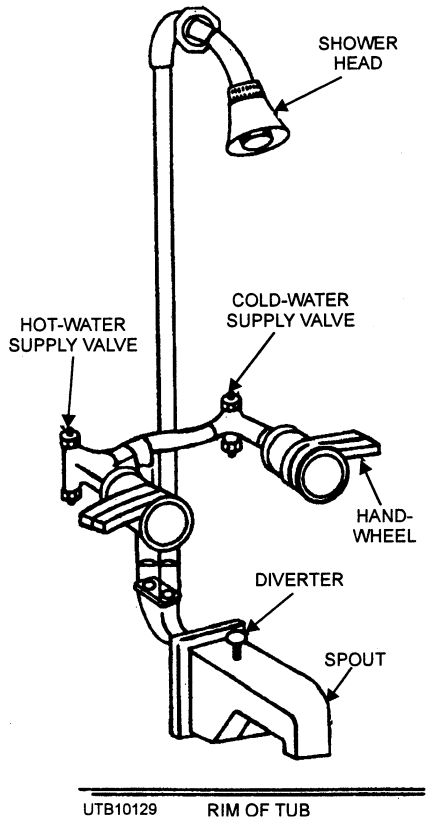


Figure 5-27.—Bathtub and shower piping arrangement.

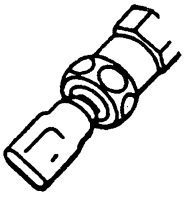
sudden changes of temperatures due to slugs of hot or cold water from varying pressures or water temperatures in the supply lines.

The pressure-controlled mixing valve, like the one shown in view A, figure 5-28, consists of a brass mixing chamber that contains a sliding piston. The piston has jets to allow hot and cold water to pass through them and mix when the handle of the valve is operated. The setting of the handle controls the water temperature by establishing the mixing ratio. A change in pressure on one side of the piston causes the piston to move and increases the flow from the low-pressure supply to maintain a nearly constant pressure.

The thermostatically controlled mixing valve, similar to the one shown in view B, figure 5-28, is sensitive to changes in both temperature and pressure. The temperature of the water delivered by the valve remains constant regardless of the temperature and pressure changes in the hot and cold waterlines. The thermostatic mixing valve is used for showers only.

The shower head is attached to a 45-degree fitting mounted on a chrome pipe. There are two general types of shower heads: circular and economy. The circular spray head shown in figure 5-29 has notches or

CIRCULAR HEAD



ECONOMY HEAD

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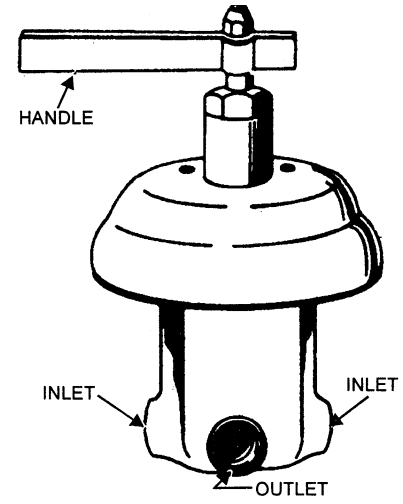
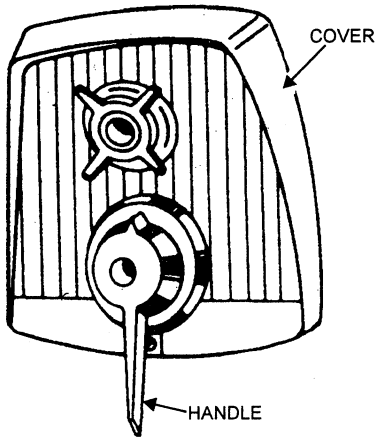
Figure 5-29.—Types of shower heads.



A. PRESSURE-CONTROLLED MIXING VALVE



B. THERMOSTATICALLY CONTROLLED MIXING VALVE

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Figure 5-28.—Shower mixing valves.

grooves around the outer edge of its face. The spray in this type of head can be regulated. The economy head, also shown in figure 5-29, has a restricted nozzle that provides a finer spray and uses less water. Both shower heads have a ball-and-socket joint for adjusting the direction of the spray.

Shower heads are usually made of chrome- or nickel-plated brass. Newer types of shower heads are made of noncorrosive plastic. Deposits tend to form on the shower head because of the chemical content of the water; therefore, occasional maintenance is required to keep them functioning properly.

The most important requirement in a shower installation is the absolute waterproofing of walls and floors. Walls are less of a problem than floors since they are subject only to splashing of water and do not have water standing or collecting on them. Careful installation of tile or other impervious material with waterproof cement generally suffices to provide a waterproof wall installation. In the installation of the floor, an impervious waterproof subbase must be put under the shower floor, or water standing on the floor will gradually seep through and cause leaks.

Concrete shower pans, used with prefabricated steel shower stalls, are relatively easy to install. In many cases, steel shower stalls are set up after the original construction. In this case, the cement base is usually not recessed into the floor but is laid directly on top of the floor.

Generally, steel fabricated shower stalls are being replaced with fiber glass and plastics. All of the units are installed in the same manner. The dimension for the finished interior of a shower stall should be at least 30 inches. The shower head should be a minimum of 68 inches above the level of the drain on the shower pan (fig. 5-30). Figure 5-31 shows a cutaway view of a shower pan. All seams should be caulked to prevent leaking, and all pipe openings in the wall of the stall should be sealed. Be sure to follow the manufacturer's instructions that accompany the fixtures and trim. In

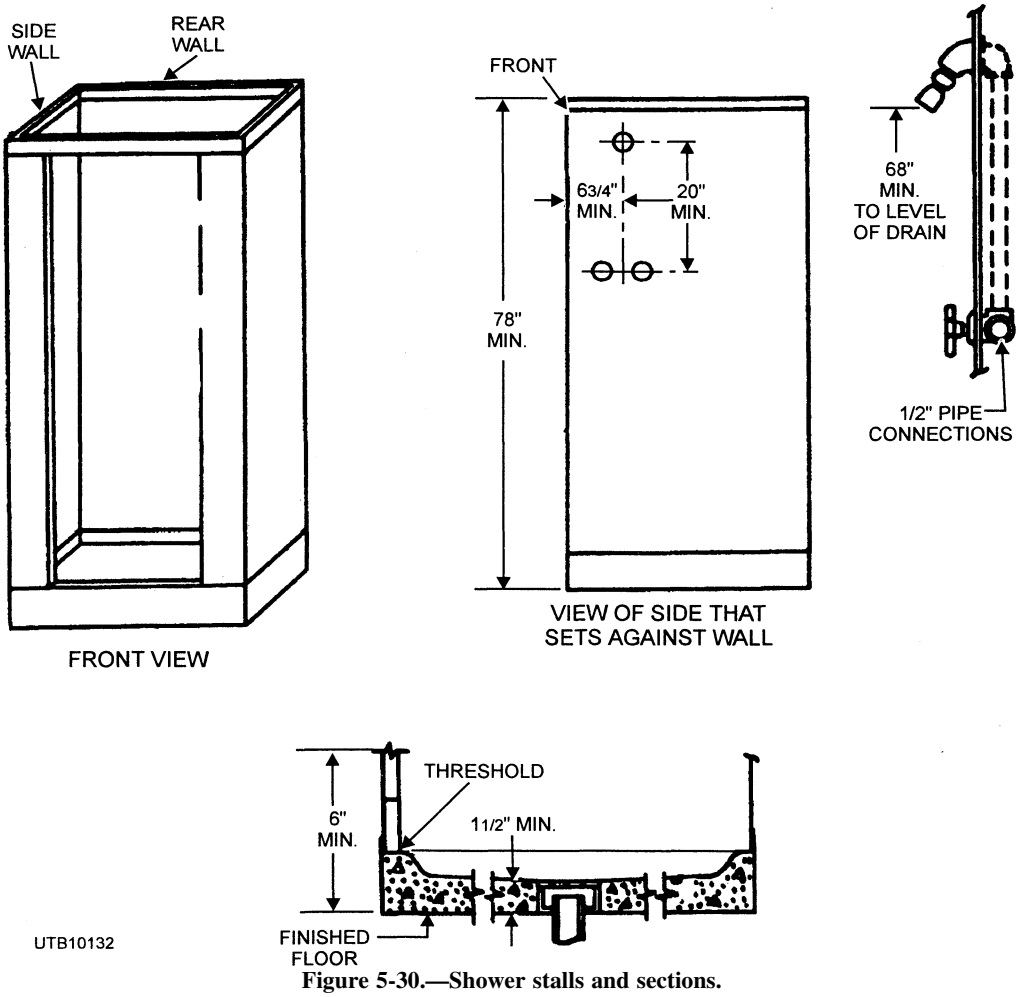


Figure 5-30.—Shower stalls and sections.

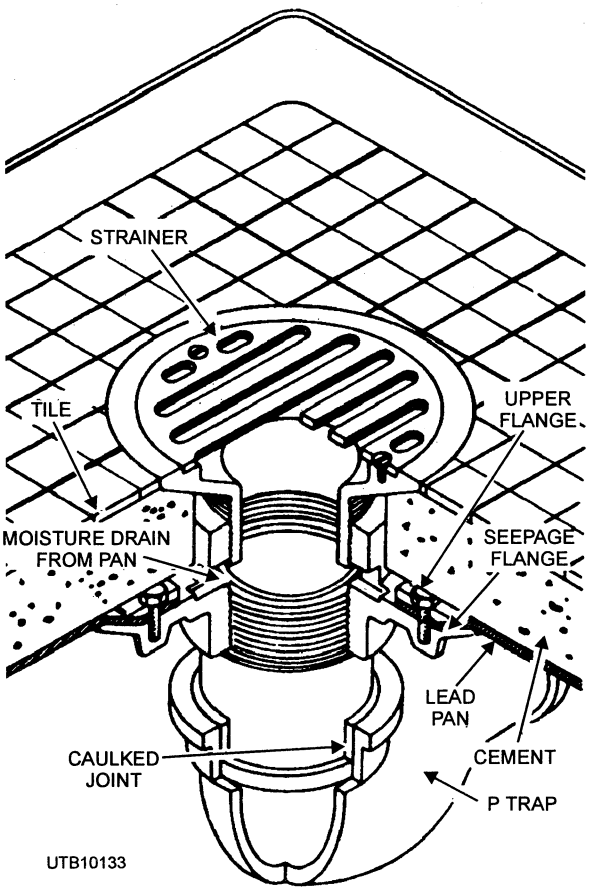


Figure 5-31.—Cutaway view of a shower pan drain.

connecting, the shower pan is connected to a P trap following the manufacturer's instructions that accompany the shower pan.

DRINKING FOUNTAINS

All types of drinking fountains should be installed with the orifice located from 30 to 40 inches above the floor, depending upon the general height of the users. One type of wall-hung drinking fountain is shown in figure 5-32. The mounting of the fixture should be sturdy and strong enough to hold more weight than that of the fixture itself. Most drinking fountains must be installed with a 1 1/4-inch P trap underneath the waste, but a few are available with integral traps. The electrically cooled drinking fountain requires an electrical outlet nearby for power. Because of the many variations in style of drinking fountains, the manufacturer's installation procedures and specifications should be followed in each case.

FLOOR DRAINS

Floor drains are used to carry contaminated water to the sanitary or storm sewer. Sanitary sewage very rarely passes through a floor drain, unless other

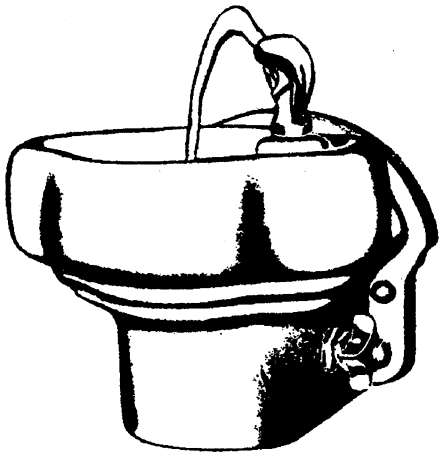


Figure 5-32.—Wall-mounted drinking fountain.

fixtures in a system overflow and sewage backs up into the floor drains.

Floor drains are divided up into two groups: those that are designed with a water seal and those that are not. Floor drains, used in connection with a sanitary sewer, by code, must have a water seal (fig. 5-33,

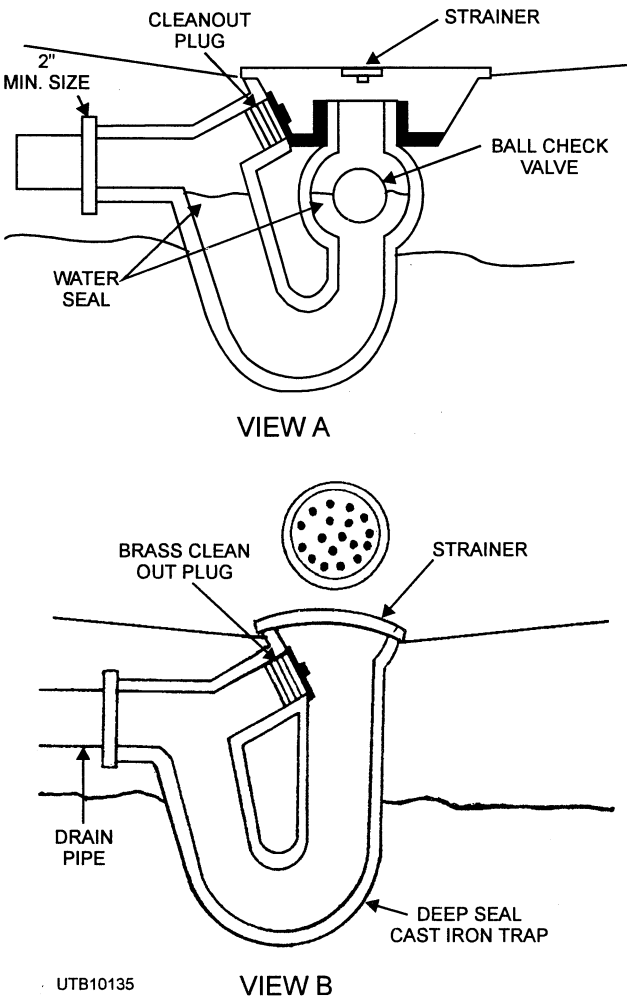


Figure 5-33.—Integral trap with ball check valve.

views A and B). The water seal prevents gases and odors from the sewer from coming into the building or structure containing the floor drain. Drains without a water seal (fig. 5-34) may be used when the floor drains are connected in a system that feeds into a storm sewer system.

A floor drain that is 2 inches is rated at two drainage fixture units. A floor drain that is 3 inches is rated at three drainage fixture units. The load of fixture units for floor drains is added to the sanitary system, not the vent system. Most code requirements do not require floor drains to be vented if they are installed within 25 feet of a vented drainage pipe line.

WATER HEATERS

Clean, hot water is required in many installations for domestic and industrial use. Since boiler water cannot be used for this purpose, because of the chemicals added, it is necessary to heat additional water. The water may be heated in tanks equipped with coiled piping through which the boiler water or steam circulates. Or it may be heated in independent units that heat by electricity, gas, solar, or oil.

Domestic water heaters are built in various sizes from 20, to 50-gallon capacities. Industrial type of water heaters are designed to heat thousands of gallons of water, depending upon the amount and use.

Modern water heaters are self-contained and require very little attention, since they are fully automatic. These units are cylindrical in shape, and they have diameters ranging from about 12 to 30, 40, and 50 inches, depending upon their capacity. The tank is constructed of galvanized sheet metal, which may be lined with a composition of glass to resist corrosion of the tank lining and prevent contamination of the water. The combustion chamber is in the lower section, which is vented by a baffled flue that extends through and ends at the top of the tank. The entire tank is insulated to prevent the escape of heat. It is also equipped with a thermostat which can be adjusted to maintain a certain water temperature. Safety features which make the hot-water heater automatic are also in the unit.

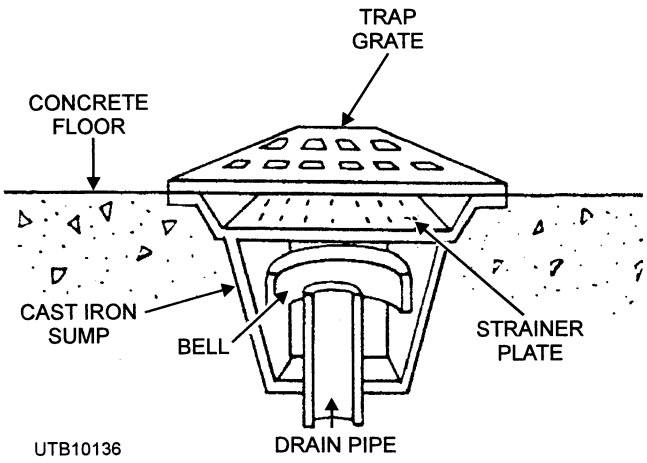


Figure 5-34.—Drain without a water seal.

Both the cold-water inlet and the warm-water outlet are at the top of the tank. These tappings are usually marked “INLET” and “OUTLET.” However, if there is a question in your mind as to which is the inlet and which is the outlet, just remember that the cold-water inlet pipe extends over halfway into the tank, but the outlet pipe does not. There is usually a drain valve at the bottom of the tank.

You must ensure the dip tube is installed on the cold-water side or inlet to allow the cold water to go to the bottom of the heater and not cool the water at the top.

Gas water heaters must be installed with a relief valve normally located in the top of the shell. The relief valve is set to open on a temperature or a pressure rise of an unsafe limit. Relief valves differ from a safety valve in that a relief valve opens gradually at a set point. Normally the valve opens at 210 degrees or at 125 psi at a minimum. The pipe that carries the relieved water or steam from the tank must extend to within 18 inches of the deck to prevent a hazardous condition.

Always remember that water in a closed vessel, when heated, will expand and cause the pressure to rise. If, for some reason, a control fails to turn the heat source off, the pressure will be relieved by the relief valve. The water that comes out of the outlet of a relief valve will flash off due to the pressure change, and you will experience a hot steam discharge along with very hot water.

Q1. What term is used to refer to measurements used to set water supply and sewer drainage piping?

Q2. One fixture unit is equal to how many cubic meters of water per minute?

Q3. Using table 5-1, how many fixture units will be used to install two bathtubs, three water closets, and a slop sink?

Q4. Does a water closet, equipped with a flushometer valve, require more or less water per flush than one equipped with a flush tank?

Q5. What are the two types of urinals most commonly used by Utilitiesman?

Q6. A service sink is referred to by a more common name. What is it?

Q7. What type of faucet is used for exterior connections?

Q8. What instruction should be used to determine riser height if the user does not indicate a preference?

PLUMBING REPAIRS

LEARNING OBJECTIVE: *Recognize procedures for making plumbing repairs and testing; recognize methods of operation for fixture hardware and safety.*

This portion of the chapter will deal with some of the more common plumbing repairs that will be necessary from time to time to keep plumbing systems operating properly. Proper repairs and maintenance techniques save money by extending the life of plumbing systems. For example, one water faucet that is leaking one drop of water each second wastes about 2,300 gallons of water per year.

WATER BREAKS

Water distribution piping at one time or another will require repair on a leak or a break in the line. The following are problems you may have during a waterline break:

- The water supply for fire protection is reduced or does not exist.
- Escaping water under pressure undermines structures, damages foundations, destroys landscaping, or causes a serious erosion problem.
- A broken pipe causes a health hazard because the distribution system can become contaminated by external sources.
- The water supply for normal domestic or industrial use can be completely cut off.

To ensure proper repair of a water break, keep red line prints on hand that show the water distribution lines, existing conditions, and locations. Ensure to red line your set of prints every time you make a repair or line change. Additionally, notify engineering of your line repair or line change, and they will update the master set of base prints.

At some activities, electronic devices are available for subsurface survey and pipe location work. Sometimes you may have to find points of interconnection, pipe diameters, and the condition of exterior surfaces or coatings. For future use, make notes on the maintenance prints to show the general condition of the system. Use a symbol that stands out to show the approximate age of the installation or its parts. Prints should be complete and up-to-date. In maintenance or repair, these prints help in planning maintenance. Many times, they offer clues to the most probable location and probable cause of trouble. Now and then, the system should be flushed through hydrants and blowoffs to remove scale and accumulation in pipes and fittings. When performing this operation, start at the hydrants or blowoffs nearest the source of supply to conserve water and to stir up less of the distribution system. Each point should be flushed until the water comes out reasonably clear. All valves should be in their normal operating positions before you go on to the next point. Flushing dead ends is vital. When flushing does not induce enough velocity to scour the mains clean, night flush them with a large discharge. Night operation lessens work disruption caused by water shutoff or decreased water pressure.

WATER MAINS

Since water main breaks must be repaired as fast as possible, personnel must be trained and repair plans made in advance. The following procedures are essential:

1. Post the telephone numbers of the fire department and key personnel and have alternate personnel available in case members of the regular repair crew cannot be reached at the time of a break. Notify the public works officer at the time the break is reported.

2. Always keep the following items readily available: valve keys, hand tools, digging tools, pavement breakers, trench shoring, a portable centrifugal or diaphragm pump, floodlights, an emergency chlorinator, and calcium hypochlorite powder.

3. Maintain enough pipe repair materials and supplies. As a temporary measure, wooden plugs can be

used to stop small holes in a main. These plugs can be replaced later with metal plugs, or repairs may be made by other means. Wooden plugs can also be used temporarily to plug the ends of a pipe up to 8 inches in diameter, but such plugs must be braced to withstand existing main pressure. After repairs are completed, the main must be disinfected. Disinfection was discussed earlier in chapter 1 of this training module.

THAWING FROZEN PIPES

In cold weather, a water-supply system can freeze. Because of the lack of protection against freezing, and, sometimes regardless of it, pipes frequently freeze in Temperate Zones. When this happens, the pipes must be thawed. Breaks must be found, if possible, before natural thawing to prevent damage to material and property. Alert personnel to watch for the signs of a broken line. The prevention of freezing pipes can sometimes be accomplished by using heat tapes and cables.

Before starting to thaw a frozen pipe, open faucets affected by the freeze. Frozen pipes can be thawed by applying heat at the lowest open end of the frozen section. (Do NOT start in the middle of a frozen section because a pocket of steam could develop and an explosion or damage to the pipe can occur.) Where there is no danger of fire, simply heat the pipe with a blowtorch, applying the flame on the outside of the pipe.

When thawing frozen water pipes or heating pipes inside of buildings, use hot water. Do NOT use an open flame. A safe method is to wrap the frozen section of pipe with cloth and pour hot water on it until the ice gives way. Remember to protect the floor by catching the water in buckets or by covering the floor with material to absorb the water.

A good method of thawing water pipes that are underground or otherwise hard to get to is shown in figure 5-35. When using this method, remove the fittings (see illustration) and insert one end of the small pipe or tube into the frozen pipe. Now add an elbow and a piece of vertical pipe to the outer end of the thaw pipe. Place a bucket under the opening to the frozen pipe and insert a funnel in the open end of the vertical pipe. With that done, start pouring boiling water through the funnel into the pipe. As the ice melts, push the thawed pipe forward. Where necessary, add pipe at the outer end until a passage is made through the ice.

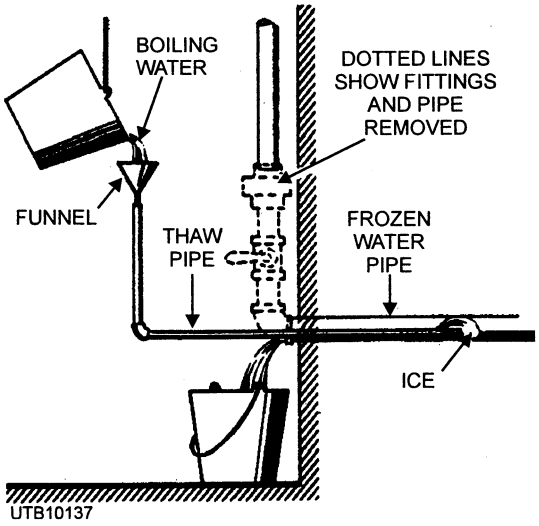


Figure 5-35.—Thawing an underground or otherwise inaccessible pipe.

Withdraw the thaw pipe quickly after the flow starts and do not stop the flow until the thaw pipe is fully removed and the pipe cleared of ice.

Instead of a funnel, a small force pump can be used. This pump is useful for thawing a long piece of pipe. When available, you can use steam in place of hot water. The above method can also be used without the elbow and piece of vertical pipe shown in figure 5-35. Simply connect the funnel to the outer end of the thaw pipe with rubber tubing. Have the tubing long enough so you can hold the funnel above the level of the frozen pipe. In this way, you give the hot water a head, forcing the cooled water back to the opening where it runs out into the pail. Hence the advantage of the elbow and vertical pipe is that they increase the head of the water and make the use of the funnel easier.

Electrical Thawing

Electrical thawing of frozen service lines is quick and cheap. The electrical current for the thawing operation consists of a source of current (a dc generator, such as a welding outfit, or a transformer connected to an ac outlet) and two insulated wires connecting the current source and the pipe (fig. 5-36). Only qualified personnel should use power lines as a source of current. As current flows through the pipe, heat is generated, and the ice within the pipe begins to melt. As the water starts to flow, the rest of the ice is melted by contact with the flowing water. The wires from the current source may be connected to nearby hydrants, valves, or exposed points at the ends of

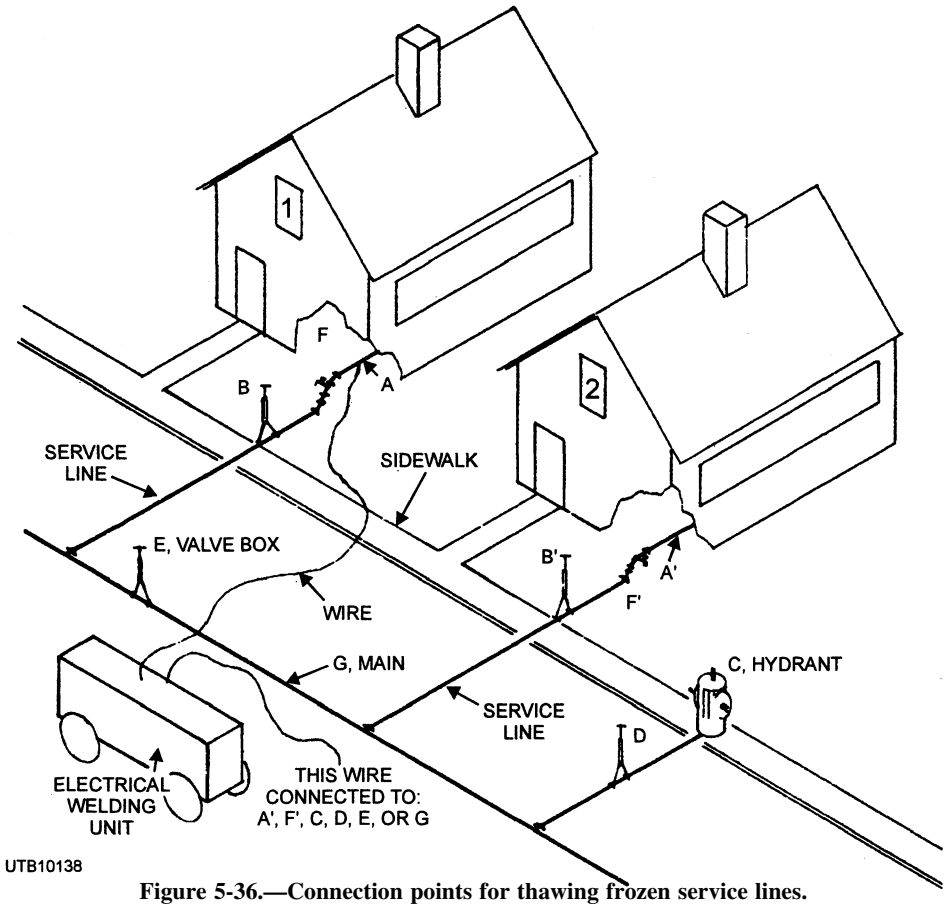


Figure 5-36.—Connection points for thawing frozen service lines.

Table 5-3.—Relation of Current and Voltage Required for Thawing

Type of pipe	Pipe Size (in.)	Pipe length (ft.)	Approximate,	Approximate (amps)
Wrought Iron	3/4	600	60	250
	1	600	60	300
	1	600	60	350
	1/2	500	55	400
	2	400	40	450
	3	400	50	500
Cast Iron	4	400	50	600
	6	300	40	600
	8			

the frozen sections. Some data on current and voltage required for electrical thawing of various sizes of wrought-iron and cast-iron pipes are presented in table 5-3.

The time for electrical thawing may vary from 5 minutes to over 2 hours, depending on pipe size and length, intensity of freezing, and other factors. The best practice is to apply current until the water flows freely.

Use the following procedures in electrical thawing:

1. DIRECT-CURRENT GENERATOR. To thaw pipes with a welding generator or similar direct-current source, set the generator to the correct amperage for the pipe to be thawed and connect the leads to the pipe.

2. ALTERNATING-CURRENT CIRCUIT. Transformers are required to adjust amperage of an

alternating-current circuit to the pipe being thawed. To reduce hazards, have a competent Construction Electrician set and connect transformers, make the connections, and assist in the thawing process. Where frequent thawing is necessary at different points, the transformers may be mounted on a trailer for ready use.

Some precautions in electrical thawing are given below.

- Avoid a higher current than listed in table 5-3. When in doubt, use low current for a longer period.
- Select contact points on the pipe as close as possible to the frozen section.
- Assure that contact points are free of rust, grease, or scale.
- Remove meters, electrical ground connections, and couplings to buildings with plumbing in the pipeline to be thawed.
- If there are gaskets or other insulation at pipe joints, thaw the pipe in sections between such joints, or use copper jumpers to close the circuit across insulated points.

Steam Thawing

Steam thawing of frozen systems is slower than electrical thawing and should be used only when insulating materials in pipes (plastic, transite, and wood), pipe joints, or couplings make the use of electricity impractical. In steam thawing, a hose connected to a boiler is inserted through a disconnected fitting and gradually advanced as the steam melts the ice.

Variation of Water Pressure

A change of water pressure can cause much discomfort to persons using the plumbing system. The mixture of hot and cold water from a shower can suddenly vary in temperature or rate of flow when water is turned on at another outlet. Failure to remedy this condition could injure somebody, especially if the temperature is scalding.

When a switch in pressure and water flow occurs often, look at the water pipes. Check the pipes to see if they are the proper size in diameter for their length and height as originally installed. Also look for liming and corrosion inside the pipes. Enough liming and corrosion can reduce the diameter of the pipe, causing low pressure and slow water flow.

Sometimes the trouble occurs after more fixtures have been installed in the system. When this happens, the piping is probably overloaded because of the extra fixtures. Pressure and water flow may also change when there is too much friction in the pipe, too many fittings, and the piping changes in direction.

If the pressure at showers changes only when other outlets are open, you can usually correct the trouble by installing automatic mixing valves. The only answer to an increase in the water flow from pipes that are too small is to replace them with larger pipes.

Q9. What is the most common repair performed on piping systems due to frozen pipes?

Q10. A 400-foot run of 4-inch cast-iron pipe requires approximately how many amperes of electricity for effective thawing if frozen??

PIPE LEAKS

LEARNING OBJECTIVE: Recognize *types of pipe and tank leaks and methods for repair.*

When a leak develops at a threaded joint of pipe, one of the most likely suspects is a fractured or ruptured pipe. Fractures often occur at the end of a length of pipe because of strain imposed by vibration of water hammer. It occurs at the end of the pipe because the wall thickness is decreased and weakened by threading. The risk of fracture becomes even greater when the threads are not cut true. In cold climates, freezing sometimes causes pipes to rupture, in which case replacement becomes necessary. A loose or cracked fitting can also cause leakage at the threaded joint of a pipe. These and other common failures resulting in pipe leakage make it important for you to determine the exact location and cause of failure before commencing any repairs to the piping.

LOCATING LEAKS

Find and repair leaks in the water piping system as quickly as possible to prevent serious damage to footings, walls, floors, plaster, and other parts of the structure, and to conserve water. Find leaks systematically by inspecting exposed piping and valves and by examining walls, floors, and ceilings around concealed piping. You should also check gauges, meters, and other water flow recording

devices for evidence of abnormal flow, which might reveal loss through leakage.

In galvanized pipe installations, where the fittings on either side of the leak are not readily available, the leaking section may be cut out. In this operation, one person holds the pipe with a wrench to keep it from turning in the next fitting, and another person cuts a thread on it while it is in place using a hand type of pipe threader. The cutout section is then replaced with a coupling, a pipe section of the required length, and a union.

You may also have to repair leaks in copper piping. If a copper pipe leaks, cut out the damaged section and replace it with a new section, using either soldered or compression-type joints. When a piece of cast-iron pipe less than full length is needed for replacement, cut it from a double-hub pipe, so the remaining piece has a hub left for use in other work.

If you need a fitting for a short space or if existing work cannot be removed easily, use short spigot ends for sleeves. Closely observe figure 5-37. This figure shows how to install a fitting in a restricted space.

Replace a fitting or insert one into an existing line by following the four-step procedure shown in figure 5-38. When the job calls for adding connections to an outside vitrified clay sewer line, here is one step-by-step method.

1. Remove a section of the existing sewer pipe that is long enough to receive a new Y-fitting.

2. Break half of the hub rim of the new Y-fitting, as shown in view A, figure 5-39.

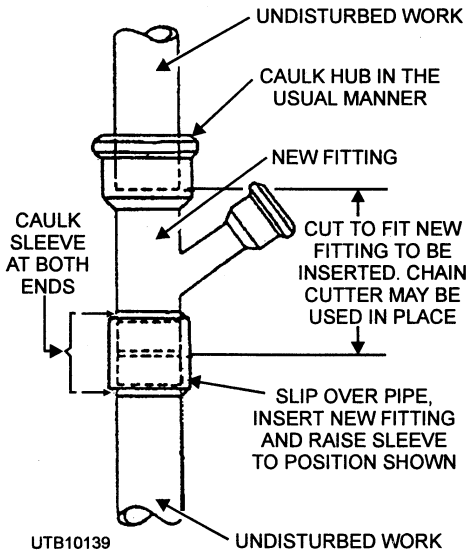
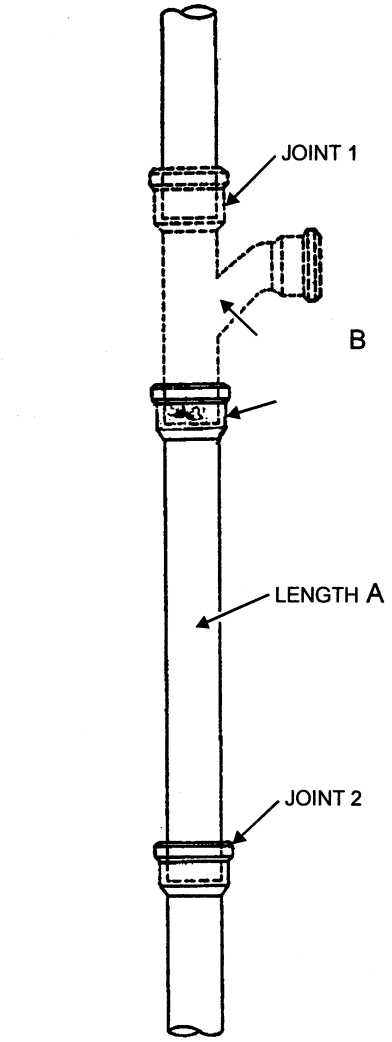


Figure 5-37.—Installing a fitting in a restricted space.



STEP 1. MELT LEAD FROM JOINTS 1 AND 2.
STEP 2. CUT PIPE A TO CORRECT LENGTH.
STEP 3. ASSEMBLE PIPE A AND FITTING B AND INSERT INTO LINE.
STEP 4. STRAIGHTEN LINE AND CAULK JOINTS 1, 2, AND 3.

Figure 5-38.—Insert a fitting in an existing line.

3. Insert the spigot end of the Y-fitting into the hub of the existing pipe. At the same time, place the remaining half of the hub end of the Y-fitting over the cut end of the existing pipe with the Y-branch pointing away from the new inlet. (See the first position of view B, fig. 5-39.)

4. Rotate the Y-fitting, so the broken half of the hub is up and the Y-branch is in the correct position to receive the new inlet connection. (See the final position of view B, fig. 5-39.)

5. Pour the joint carefully; round over the broken half of the hub with plenty of concrete or mastic compound, as shown in view C, figure 5-39.

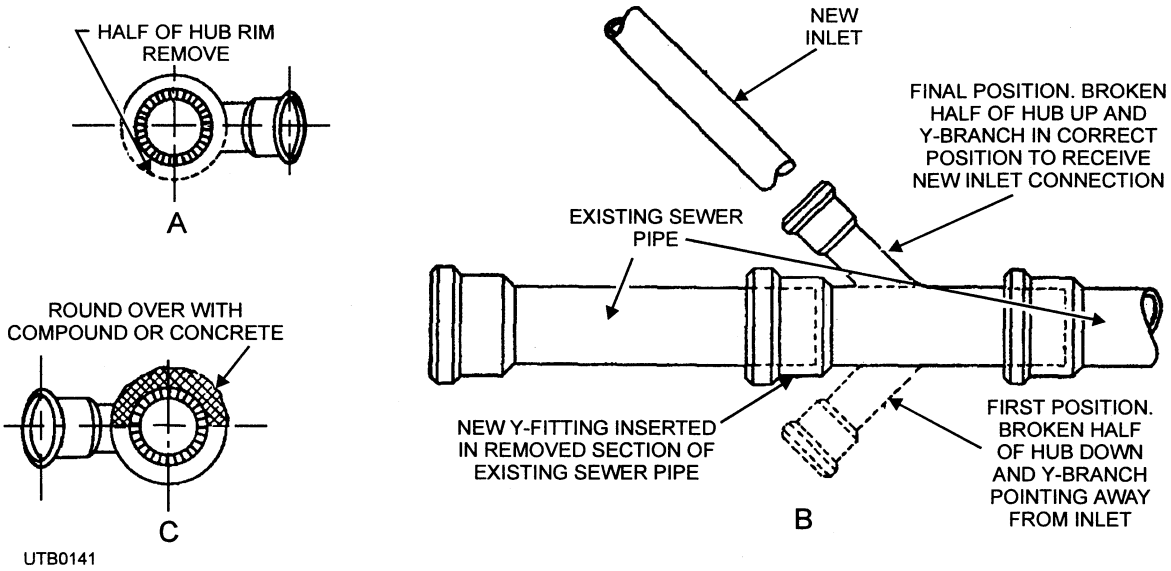


Figure 5-39.—Adding connections to an outside vitrified clay sewer pipe.

EMERGENCY TEMPORARY REPAIRS

At times, a pipe may start leaking and the materials needed to repair it permanently are not on hand. Here, you may have to use a temporary or emergency repair. Keep in mind that a permanent repair should always be made when the proper tools or materials are available.

One simple method of making a temporary repair of a leaky pipe is to use a length of rubber hose. After turning off the water supply, remove the defective section of the pipe by cutting it with a hacksaw. Then take a piece of rubber hose, slightly longer than the section of pipe you removed, and slip it over the ends where the cut was made (view A, fig. 5-40). Ensure the inside diameter of the hose matches the outside diameter of the pipe. Hose clamps hold the hose securely in place.

Another temporary method of repair for a leaky pipe is to wrap the leaky area with sheet rubber. Then place two sheet metal clamps, one on each side of the pipe, on the sheet rubber covering, as shown in view B, figure 5-40. Now, fasten the clamps with bolts and nuts. Sheet metal clamps for this type of repair can be made from scrap material from the sheet metal shop. You may want to make up a few of these clamps to keep on hand for an emergency repair job.

You can also secure the water supply, drain the water from the pipe, clean the pipe surfaces thoroughly, apply flux, and then wrap clean copper wire over the rupture and solder.

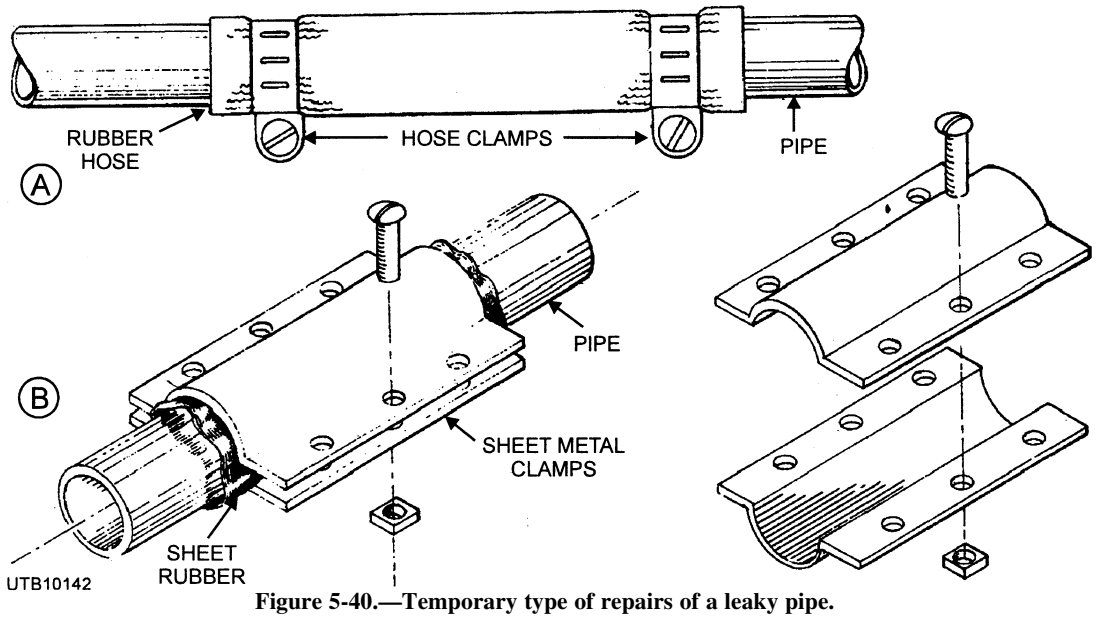


Figure 5-40.—Temporary type of repairs of a leaky pipe.

WATER TANK FAILURES

Where a plumbing system has been in use for some time, two failures in water tanks are (1) leaky seams and (2) corroded areas requiring welded patch plates. To repair a defective seam, first drain the water tank dry. Then clean the surfaces to be repaired until they are right. By welding or brazing, you can then make the leaky portions watertight.

As an effective tank patch for a large hole, you need both a temporary and a permanent patch. One temporary patch is a tapered softwood plug. Insert the plug in the hole, and tap it lightly with a hammer until the seal is watertight. Then saw off the top of the plug, so it is flush with the tank wall.

Next, the area around the plug to be covered by the permanent patch should be cleaned by wire brushing. Drain the tank; now you are ready to apply the permanent patch. One type of permanent patch includes a rubber gasket and a metal plate. Rubber sheeting, at least 6 inches by 6 inches and l/16 inch thick, may be used for the gasket, and it should be centered on the plug and cemented with adhesive. The patch plate of black steel or nonferrous (no iron) metal should be of the same material and thickness as the tank wall but a lot larger than the hole. Cover the hole with the metal plate, keeping an equal overlap around the edges, and braze or weld the plate to the tank, using a continuous seam.

Q11. What is the most common reason a threaded pipe joint will leak?

Q12. Water tank failures normally occur due to what two causes?

WATER CLOSETS

LEARNING OBJECTIVE: Understand operation, maintenance, and repair of water closet flush tanks.

Moisture on the floor at the base of a water closet bowl usually means the seal or gasket between the closet and its outlet has failed; however, it can result from condensation on the tank or piping or from leakage of the tank, flush valve, or piping. When the seal leaks, remove the water closet bowl and install a new seal to prevent damage to the building. This also prevents entry of sewer gas into the room.

In servicing plumbing fixtures, you have the job of clearing stoppages in water closets. Information on tools and chemicals used in clearing stoppages in water closets and other fixtures is given later in this chapter.

FLUSH TANK

Knowing the principles of operation of a flush tank will enable you to find the source of trouble when a flush-type water closet tank is not operating properly. For clarity, all of the parts of a flush tank have been labeled in figure 5-41. Keep in mind that in different types of flush tanks you may find some change in the method of operation.

Table 5-4 explains the principle operation of a water closet flush tank. Simple though it may seem, you must understand the operation to troubleshoot an inoperative flush tank.

FLUSH TANK REPAIRS

When water continues to run into the closet bowl after the flush tank is full, the trouble is in some part of the inlet valve assembly (ball cock assembly) or the stopper valve is not seated. The plunger has failed to close the inlet valve as it should, and thus the excess water that continues to flow in (after the tank has reached the proper level) is being discharged through the overflow pipe and into the bowl.

In checking for the source of trouble, several defects to look for are a leak in the float ball, a bent float arm, a worn washer on the bottom of the plunger,

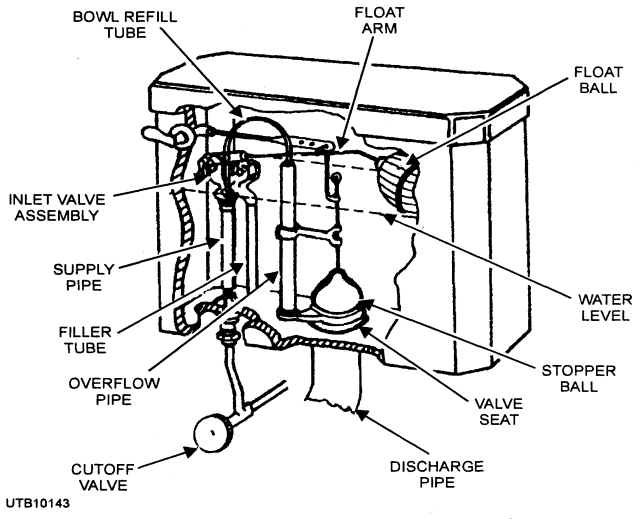


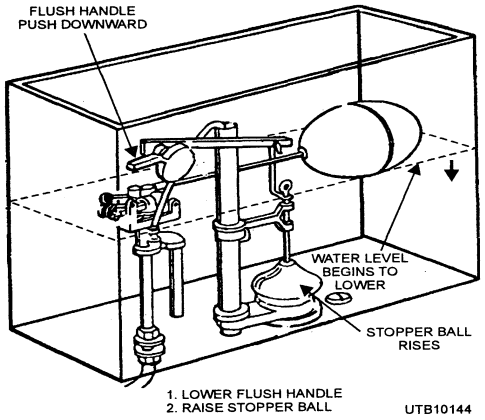
Figure 5-41.—Water closet flush tank.

Table 5-4.—Flush Tank Process

STAGE 1

When the flush handle is pushed downward, the rubber stopper ball is raised from the valve seat to allow the water from the tank to go into the discharge pipe.

When the flush handle is pushed downward, the rubber stopper ball is raised from the valve seat to [illegible] water from the tank to go into the discharge

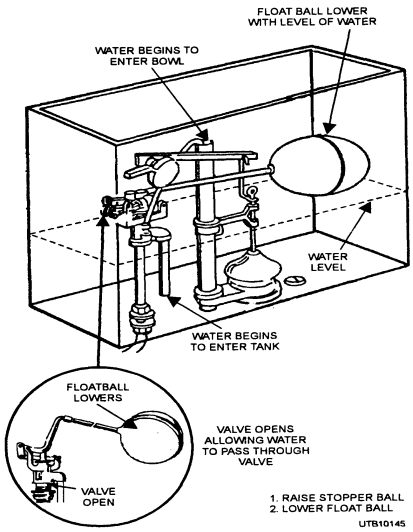


STAGE 2

STAGE 2

As the water lowers in the tank, the float ball lowers and the movement of the float arm opens the inlet valve, allowing water to start flowing into the tank slowly.

As the water lowers in the tank, the float ball lowers and the movement of the float arm opens the inlet valve, allowing water to start flowing into the tank slowly.



STAGE 3

STAGE 3

As the water flows from the tank to the discharge pipe, the stopper ball seats and incoming water holds the ball in place and the tank fills.

ball in place and the tank fills.

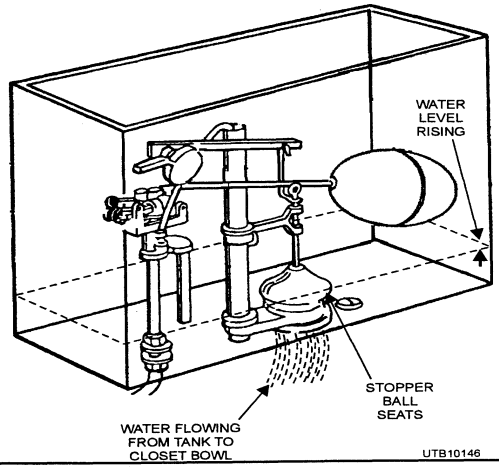
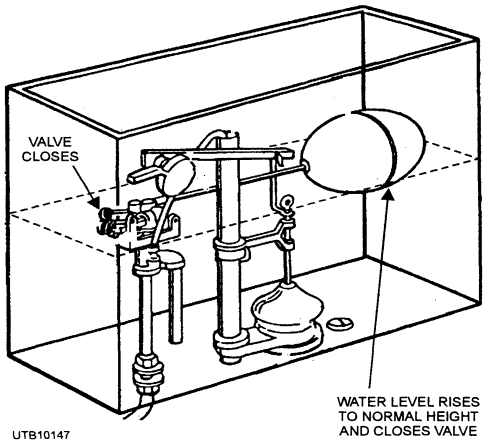


Table 5-4.—Flush Tank Process-Continued

STAGE 4
STAGE 4 As the water continues to fill the tank, the float ball rises until the float ball arm allows the valve to close. rises until the float ball arm allows the valve to close.



or a worn valve seat. Start with the float ball, keeping in mind that a leaky, waterlogged float prevents the plunger from closing properly. A small leak in a copper float ball can be remedied by soldering. If it has a large leak, though, simply replace the float ball with a new one. A damaged float arm should also be replaced with a new one. Sometimes the float arm is bent or does not allow the valve to close. In this case, bend the float arm downward a bit to push the valve tighter into its seat. To replace the washer on the bottom of the plunger (view B, fig. 5-42), start by shutting off the water. Now, unscrew the two thumbscrews that pivot the float rod lever and the plunger lever (view A, fig. 5-42). Push the two levers to the left, drawing the plunger lever through the head of the plunger. Now, lift out the plunger, unscrew the cap on the bottom, insert the new washer, and reassemble the parts. If the cap is badly corroded, replace it with a new one. When replacing the washer, examine the seat for nicks and grit. The seat may need regrinding.

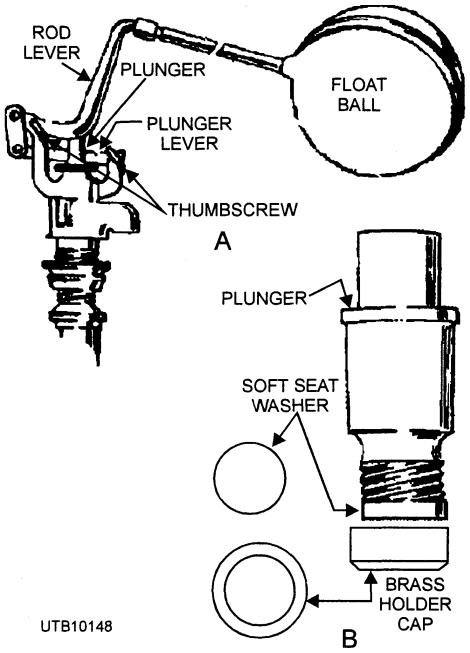


Figure 5-42.—A. Ball cock assembled; B. Plunger washer and cap.

Suppose water continues to run into the closet bowl after flushing, yet the tank does not refill. Some part of the FLUSH VALVE assembly is at fault because the flush valve is not closing properly. To locate the trouble and get the tank back in order, proceed as follows:

First, stop the inflow to the tank by holding up the float ball or supporting it with a stick. Then drain the tank by raising the rubber stopper ball or the flapper. Now, examine the stopper ball to see if it is worn, out of shape, or has lost its elasticity. If either condition exists, unscrew the lower lift wire from the ball and replace the ball with a new one; or if it is a flapper valve, remove the flapper and replace it. There are no lift wires or wire guides to adjust on the flapper valve type of flush valve. Ensure the lift wire is easily fitted over the center of the valve by means of the adjustable guide holder. By loosening the thumbscrew, you can raise, lower, or locate the holder over the overflow tube. The horizontal position of the guide is fixed exactly over the center of the valve by loosening the locknut and turning the guide screw.

The upper lift wire should loop into the lever arm hole directly above the center of the valve. The tank should empty within 10 seconds. Because of lengthening of the rubber ball and insufficient rise from its seat, the time needed to empty the tank may be longer than 10 seconds and the flush weak. In this case,

shorten the loop in the upper lift wire. Also, a drop or two of lubricating oil on the lever mechanism makes it work more smoothly.

If you have a water closet tank that sweats and drops water on the deck, check the temperature of the water in the tank. If the temperature is very cold, this is the problem. The moisture that is in the air surrounding the tank is condensing on the tank. The solution to the problem is (1) place a terry cloth on the tank to catch the water, (2) place a styrofoam insert in the tank, or (3) install a water tempering valve, which places some warm water in the tank while the tank is filling.

Q13. *A water leak at the base of a water closet tank normally indicates what type of problem?*

Q14. *When water continues to run in the water closet bowl after the tank is fill, what most likely is the cause?*

FLUSHOMETERS

LEARNING OBJECTIVE: *Identify the types of flushometer valves, their operation, and methods of repair.*

Two major problems with flush valves are (1) the valve may run continuously, instead of shutting off at the right time, or (2) the valve may fail to deliver the desired amount of water (short flushing). Since flush valves are installed to avoid waste, they must be properly maintained. Once you understand the operation of a valve, you can keep a flushometer in good repair.

OPERATION OF DIAPHRAGM FLUSHOMETER

Table 5-5 shows the operation of a diaphragm-type flushometer. Read through the table and study the diagrams until you thoroughly understand the operation of the valve.

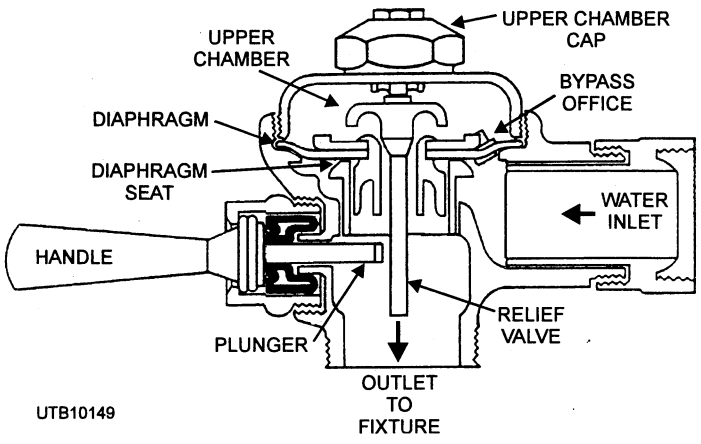
OPERATION OF A PISTON-TYPE FLUSHOMETER

The piston-type flushometer valve shown in figure 5-43 is opened by a lever which discharges the water from the dashpot chamber. The reduced water pressure in the dashpot chamber then forces the piston assembly upward, which allows the water to enter the fixture. The closing of the valve is automatically controlled with a bypass through which the water enters the

Table 5-5.—Operation of Diaphragm Flashometer

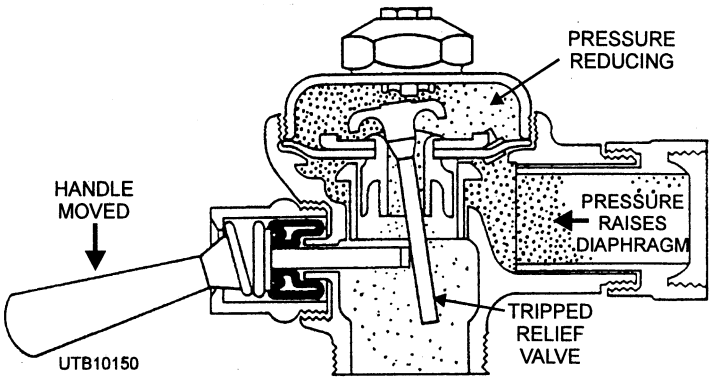
STAGE 1

The diaphragm valve is in the ready position with all of the parts labeled. In this position the upper and lower chambers contain the same amount of pressure. Therefore, the diaphragm remains seated on the seat.



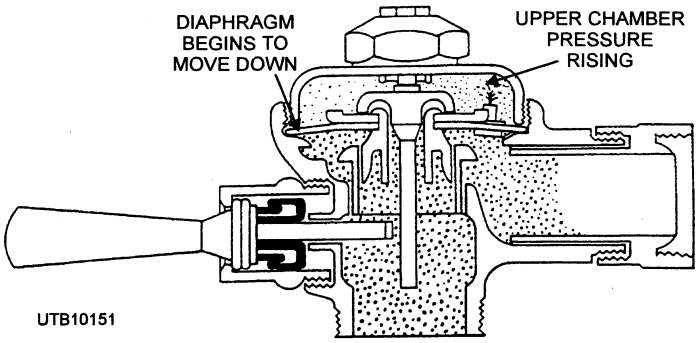
STAGE 2

When the handle is moved in any direction, the plunger opens the relief valve, which allows the water from the upper chamber to flow into the lower chamber and causes the diaphragm to rise off of its seat. Water now continues to flow down the barrel and into the fixture.



STAGE 3

As the valve lifts the diaphragm, water begins to flow slowly through the bypass orifice until the pressure rises enough to equalize the pressure in the upper and lower chambers, seating the valve.



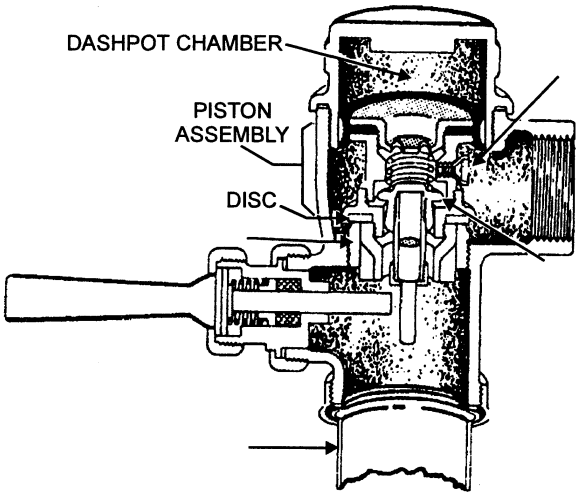


Figure 5-43.—Piston-type flushometer valve.

dashpot chamber. This forces the piston assembly down onto its seat and stops the water flow. The closing of the valve is regulated by a screw that controls the amount of time the valve stays open.

REPAIRS

Flush valves give years of adequate and trouble-free operation when they are properly installed and maintained. Continuous flow of water through a piston type of flush valve is almost always caused by failure of the relief valve to seat properly or by corrosion of the bypass valve. In both cases, there is not enough force on the piston to force it to seat. If the relief valve fails to seat as it should, the leakage may be enough to prevent the upper chamber of the valve from filling, and the piston remains in the OPEN position.

Inspect the relief valve seat for dirt or other foreign substances that may be causing the relief valve to tilt; disassemble the piston, wash the parts thoroughly, and reassemble. Replace washers that are worn, making sure that the surface upon which the washer sets is perfectly clean; scrape off old rubber if any sticks to the metal surface.

Corrosion of the bypass valve in the center of the top plate also causes continuous flow; the water cannot pass into the upper chamber of the valve, and no force is exerted on the piston to move it downward to its seat. Very dirty water passing through the system can clog the bypass and deprive the upper chamber of water. When pipelines in a new installation are not thoroughly flushed before they are placed in operation, the pipe dope or dirt in them can stop up the bypass valve.

Likewise, in a diaphragm valve, if chips or dirt carried by the water lodge between the relief valve and the valve seat, the relief valve cannot seat securely. The water leakage prevents the upper chamber of the valve from filling with water. The valve then remains in the OPEN position, since there is no pressure to force the diaphragm to its seat.

Short flushing can occur in a diaphragm type of valve. If the valve seat, diaphragm, and guide cover have not been tightly assembled, you should reassemble the valve to ensure proper operation. Sometimes you may find the bypass tube has been tampered with, enlarging it so the water passes rapidly into the upper chamber and closes the valve before the desired volume is delivered. Also, someone may have oiled or greased the valve parts to make the valve operate more easily. What actually happens is the oil or grease swells and ruins the rubber parts, interfering with the action of the valve.

Another commonly used unit is the pressure-valve-head flushometer (fig. 5-44). The most common problem with this type of flushometer is the rubber cap. To replace the rubber cap is a simple task; remove the retaining screws, lift out the plate, and remove and replace the cap.

Q15. What are the two types of flushometers used by Utilitiesman?

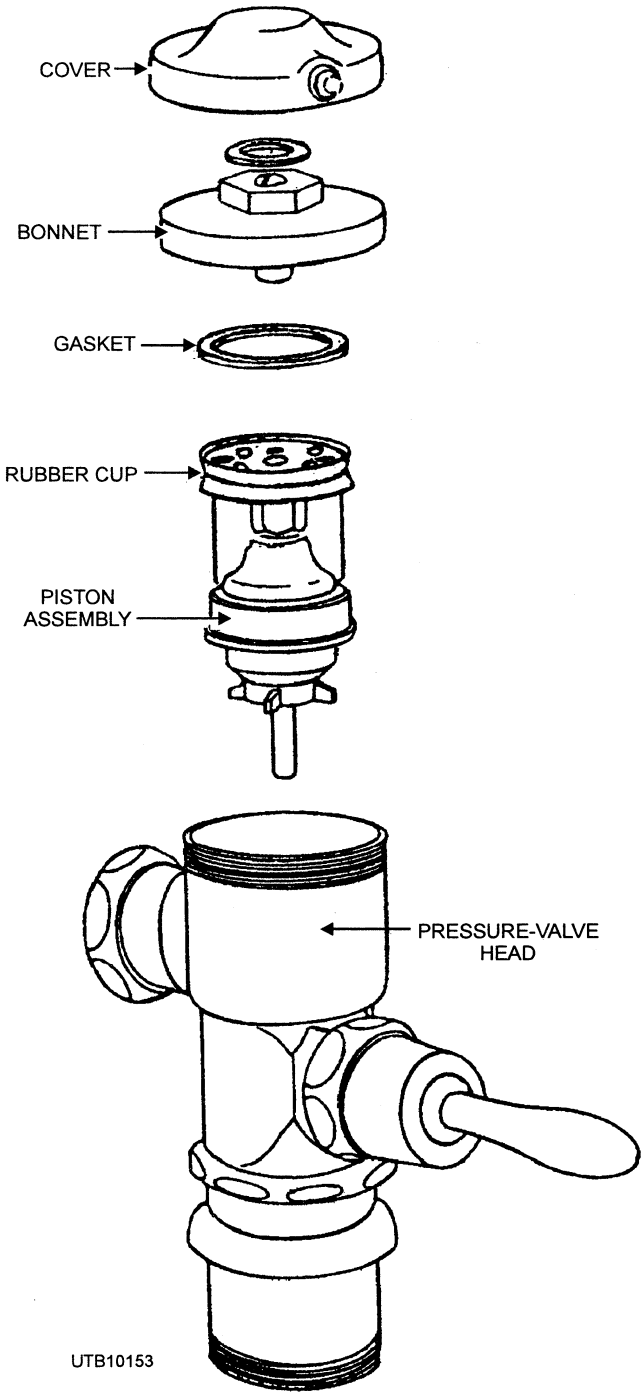


Figure 5-44.—Pressure-valve head flushometer.

Q16. What is the cause when water continuously flows through a piston-type flush valve?

Q17. What happens to a diaphragm flush valve if oil or grease is used on interior parts?

FAUCETS

LEARNING OBJECTIVE: *Recognize repair procedures and maintenance of faucets.*

There are many different types of faucets used in plumbing installations. If you can repair the compression washer faucet, you should have no trouble in repairing other types of faucets. A cutaway view of a compression faucet is shown in figure 5-45. This faucet, with a disc washer and a solid or removable seat, requires frequent attention to maintain tight closure against water pressure.

When a faucet is turned off, the washer on the end of the stem rubs against the seat. Frequent use wears down the washer and eventually causes the faucet to drip. A small, steady leak in a faucet wastes water. The remedy for a dripping faucet is simply to replace the washer. Be sure to replace flat or beveled washers with washers of the same design.

STANDARD FAUCETS

To repair a standard washer faucet, follow the steps below.

1. First, shut off the water supply to the faucet and open the faucet all the way.

2. Now, remove the faucet handle, bonnet, and stem.

3. Next, remove the brass screw holding the washer to the bottom of the spindle. Replace the washer with a new one which is flat on one side and slightly rounded on the other, so it can get both horizontal and vertical pressure and provide a firm seat. Use a good quality hard-compositionwasher because leather or soft

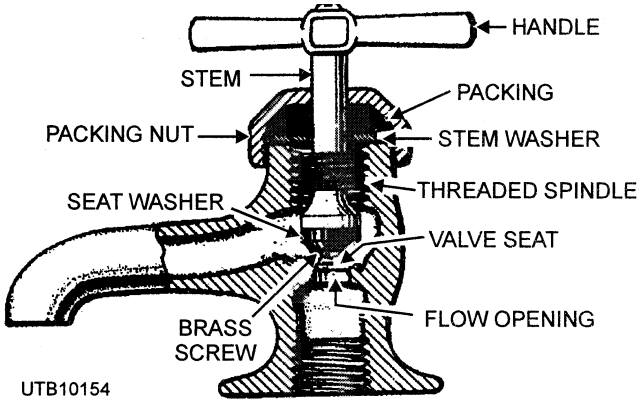


Figure 5-45.—Compression faucet.

washers do not give long service, particularly in hot-water lines.

4. If the brass screw is in poor condition, replace it with a new one (view A, fig. 5-46).

5. Examine the valve seat and repair or replace it with a new one (view B, fig. 5-46), if necessary, before replacing the spindle; otherwise, a new washer provides adequate service for only a short time.

6. Reface or ream solid seats (view C, fig. 5-46) with a standard reseating tool consisting of a cutter, a stem, and a handle. Rotate the tool with the cutter centered and held firmly on the worn or scored seat. Take care to prevent excessive reaming. Remove all grinding residue before reassembly. A solid seat can be replaced with a renewable seat by tapping a standard thread into the old solid seat and inserting a renewable seat.

7. Remove renewable seats with a regular seat-removing tool or Allen wrench. When the seat is frozen to the body, apply penetrating oil to loosen it. Faucet seats can usually be tapped, reseated, or replaced without removing the faucet from its fixture.

8. To stop leakage at the bonnet, replace the stem packing and the bib gasket.

Occasionally, you may find ball-bearing washer holders installed in faucets at some activities. The ball bearings between the stem and washer holder permit movement of the "washer" free of the movement of the stem. This allows the washer to stop its rotation on the slightest contact with the seat, thereby reducing the frictional wear of the washer.

SHOWER HEADS

Shower heads that supply an uneven or distorted stream can usually be repaired by removing the perforated faceplate and cleaning the mineral deposits from the back of the plate with fine sandpaper or steel wool. You can open clogged holes with a coarse needle or compressed air.

Q18. Which part of a faucet requires the most frequent maintenance and repair?

Q19. When a stem washer wears out, you replace it with what type of washer?

SEWER MAINTENANCE AND REPAIR

LEARNING OBJECTIVE: *Recognize methods for maintenance and repair of sewer systems.*

When you are working with sewers, most of your troubles are with stoppages and breaks. A common cause of a stoppage in a sewer system is tree roots.

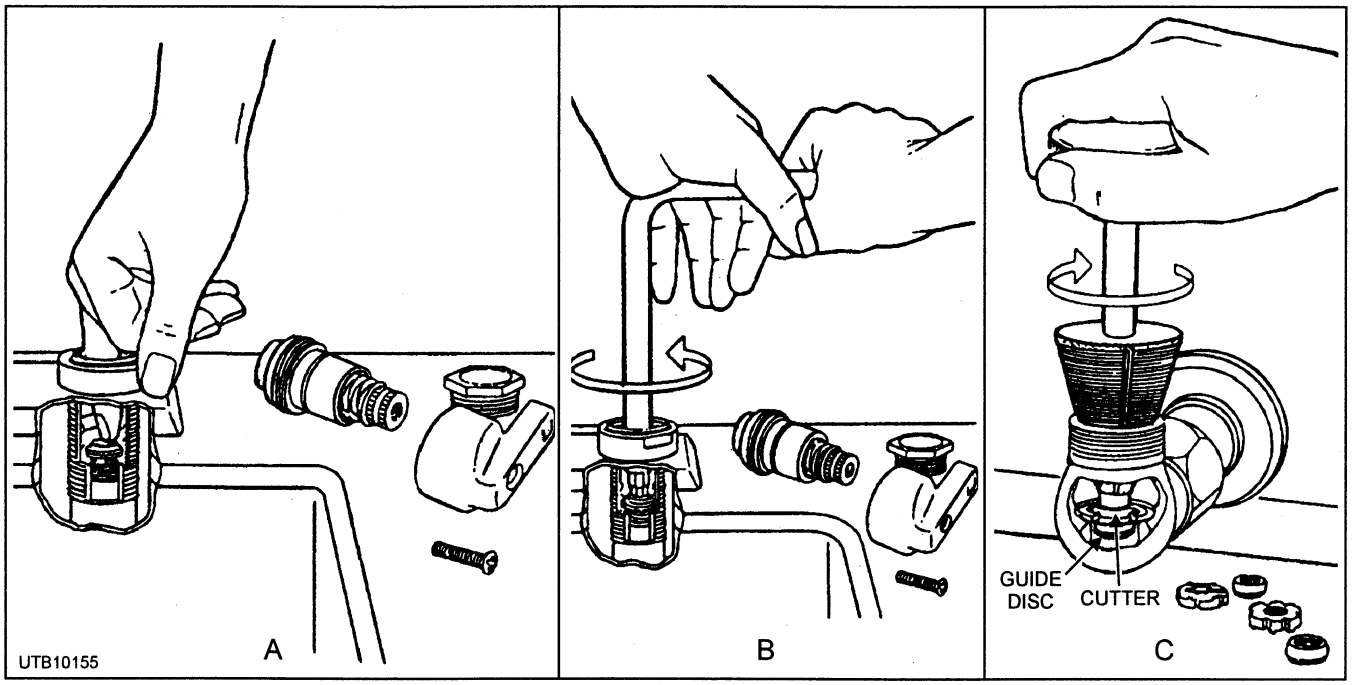


Figure 5-46.—Inspecting, removing, and refacing faucet seats.

Other causes include sand, gravel, and greasy or tar-related materials. A lot of sand, gravel, or just plain mud reveals a broken or loose sewer joint or pipe.

Explosions in sewers are not uncommon and should be guarded against. Check with your local safety office for the most current regulations and information. Systematic inspection and maintenance permit early correction of faults before major defects and failures develop. Trouble calls concerning stoppages or slow drainage are received occasionally.

The first step in correcting the trouble is to determine the cause. A sewer line can be inspected from manhole to manhole by using a flashlight or a reflecting mirror or both. One person acting as an observer can look up the sewer line toward the flashlight held by the second person in a preceding manhole. Thus the condition of the line can be noted to determine whether roots or other obstructions need cleaning out.

Before entering a manhole, ensure the air is safe. You are NOT permitted to enter a manhole until you have an entry permit, identifying all of the conditions that must be satisfied before the entry begins. Additionally, an attendant person shall be stationed outside the manhole at all times. The attendants sole responsibility will be for observation of the entrants into the manhole. The attendant shall have no other responsibilities or duties during the observation. For more information on entering confined spaces, refer to EM 385-1-1, *Safety and Health Requirements Manual.*

Purging or a fresh air pump may be required. Sewage gases are very toxic as well as explosive. Routine sewer maintenance includes flushing, cleaning, and immediate repair of defective sewers. Information pertaining to flushing, cleaning, and repairing sewers is given below.

FLUSHING

Flushing helps remove loose organic solids and sand or grit deposits from sewers. Flushing is not an efficient method of sewer cleaning unless a high velocity can be maintained between manholes on a short run; in other words, you depend on the high velocity for complete scouring action of the sewer. Flushing may be done by a number of methods, two of which are with a fire hose and with a pneumatic ball. When flushing with a fire hose, you need enough fire hose to reach between manholes. When using this method, string a rope or light cable through the sewer with sewer rods if a plain fire nozzle is used. Start at the upper end of the system and draw the flowing nozzle through the sewer. If a self-propelling turbine type of nozzle is used, the rope is not required. Try to use 2 1/2-inch fire hose discarded by the Fire Department. Paint the sewer-flushing hose at the ends with an identifying color (yellow, non-potable water) to prevent use for emergency potable water connections.

In pneumatic-ball flushing, inflate a light rubber ball, such as a beach ball or volleyball bladder, to fit snugly in the sewer, and place it in a small canvas or burlap bag with a light rope attached. Place the ball in the sewer, hold the line until the sewage backs up in the manhole, and allow the ball to move to the next manhole. When an obstruction is reached, the pressure pushes the ball against the crown of the sewer, causing a jet at the bottom (fig. 5-47). As much as 4 miles of sewer can be cleaned in 8 hours by this method, and it works for sewers up to 30 inches in diameter. A wooden ball with a diameter of 1 inch less than the sewer can also be used. Where sewage flow is low, the addition of water to the upper manhole may be required. In the sand cup method, a sand cup with an auger is attached to flexible steel sewer rods to run through the sewer (fig. 5-48). The rubber cup is perforated to provide flushing action.

WATER PRESSURE BAG (BLOW BAG)

Water pressure bags are made of various types of rubber and canvas material. The blow bag is very efficient and requires less time to operate than other types of drain cleaning equipment. Various sizes of the blow bags are available. To operate a blow bag, connect a water source to one end and insert the blow bag into the line to be cleared or flushed. Ensure that you are using a blow bag that is compressed when placed into the line. When the water pressure is turned on, the blow bag will expand in size, increasing the pressure and holding the blow bag in the line. Keep in

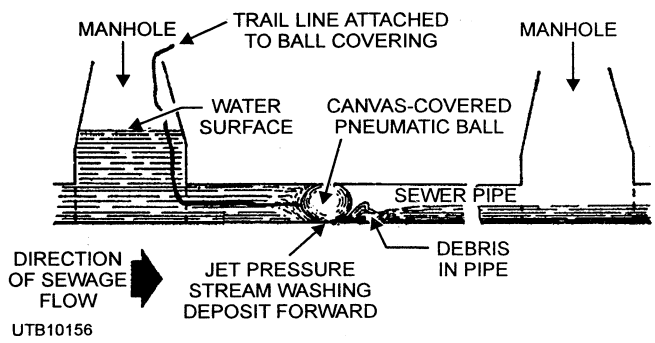


Figure 5-47.—Ball method of sewer flushing.

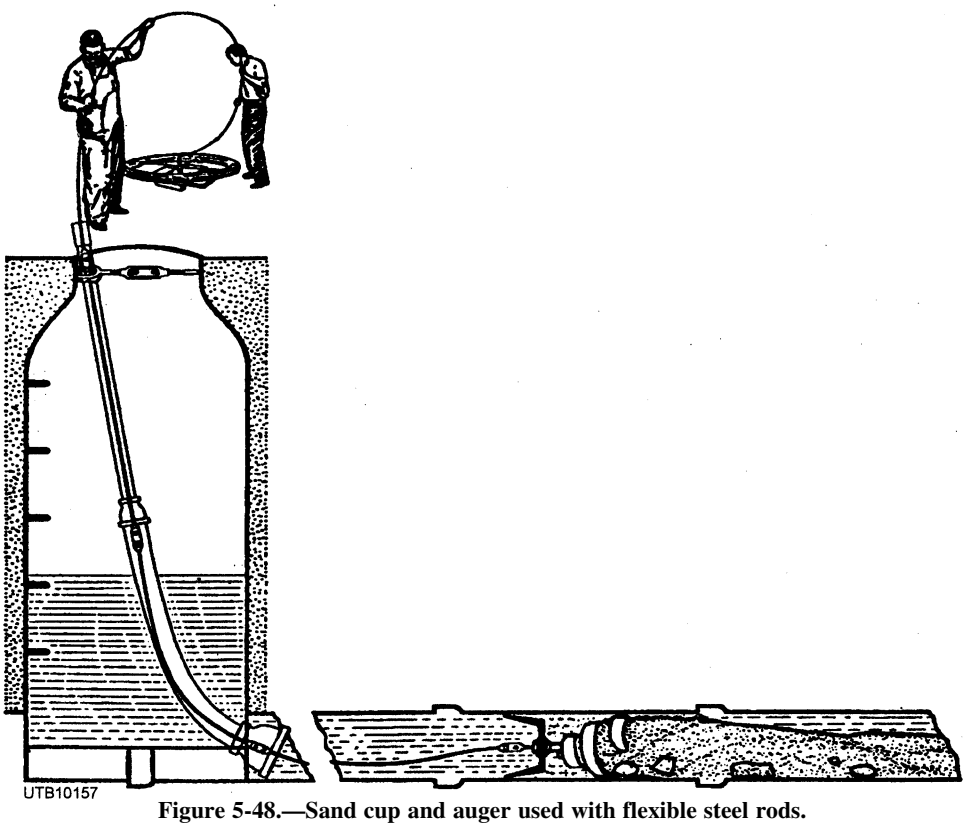


Figure 5-48.—Sand cup and auger used with flexible steel rods.

mind that once the water is turned on, any lines connected will receive high-pressure water. We do not want to turn water closets and lavatories into cool water geysers or bidets.

CLEANING

In routine sewer cleaning, the usual way is by putting a tool through the line to indicate a clean sewer, by removing partial obstructions, or by determining the necessity for a detailed job, such as grease removal, root cutting, or sand removal.

Sectional wooden sewer rods, to which a variety of end tools may be attached, have been used in sewer cleaning for many years. End tools for piercing an obstruction first, and cutters and scrapers for root and grease removal are available. Rods are pushed into the sewer from the bottom of a manhole. A device, as shown in figure 5-49, is useful for pushing the rods. Wooden rods are useful for stringing a cable through a partially obstructed sewer.

Another method of sewer cleaning is to use lightweight, spring-steel sectional rods coupled into a continuous line with several types of augers and sand cups as end tools (fig. 5-50). The tool and rod are fed into the sewer until the obstruction is reached; then the obstruction is removed by the following methods-by twisting the rod by hand, by using a small gasoline engine, or by an electric motor drive unit.

NOTE

When using power-driven equipment, ensure that it is maintained under the manufacturer's recommendations.

Flushing methods described in the previous section remove all but heavy sand deposits. Accumulated sand and grit dislocated by flushing should be removed from the sewer at a manhole. A sand trap, made from a stovepipe ell and sheet metal to

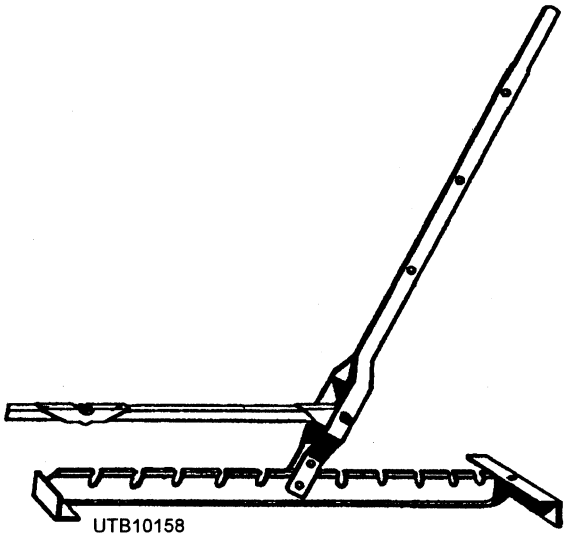


Figure 5-49.—Pushing device for wooden sewer rod.

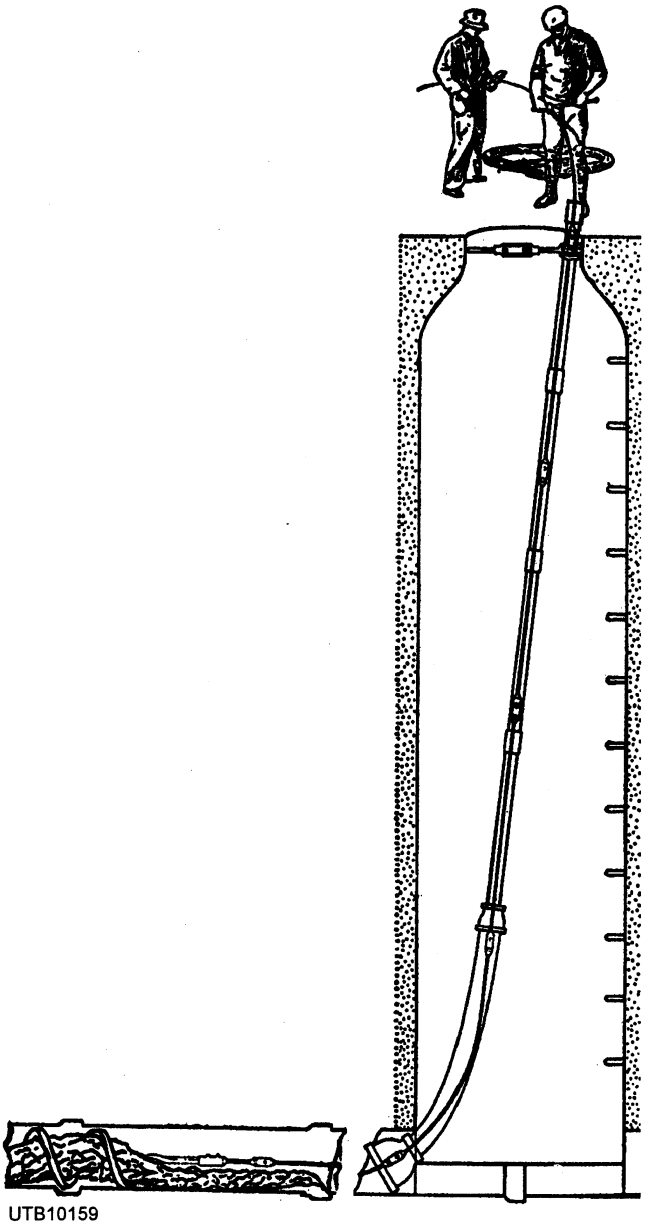


Figure 5-50.—Root removal by steel rod and auger, manual operation.

fit the sewer pipe, may be used, as shown in figure 5-51, to collect the sand. Commercial traps are available with adjustable slots to lower the water level below the top of the trap. Sand is removed by scoops or buckets.

For heavy sand deposits, a cable-drawn bucket is used, especially for storm sewers and larger sanitary sewers. The cable may be pulled by a hand winch, by a power winch, or by a truck with the cable through an anchored sheave. The sewer can be damaged if the bucket catches on misaligned joints, improper house connections, or other fixed obstructions, especially with power-driven buckets.

Turbine-driven tools (fig. 5-52) clean sewers with difficult obstructions and grease coatings. These tools

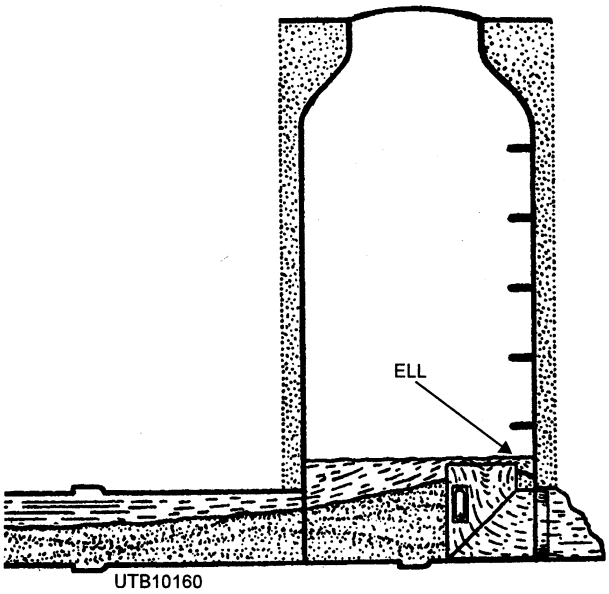


Figure 5-51.—Sand trap.

are powered by water under pressure from a fire hose. The tool and hose are pulled through the sewer by a cable.

Various types of power-driven sewer-cleaning machines are available. These machines normally have a 3/4-horsepower electrically reversible motor and weigh about 90 pounds. They are especially designed for clearing sewer pipelines, ranging from 1 1/2 inches to 10 inches in diameter and up to 200 feet in length. Some have a cable counter indicator, so the operator knows the distance the tool is in the line. Others have a headlight to aid you in working the dark areas.

A major difficulty with sewer systems buried in the ground is tree ROOTS. These are hard to detect just by looking in the manholes. With trees growing rather close to a sewer line, you can expect roots to cause a break in the line. Such trees as poplars, willows, and elms are the most troublesome when it comes to root growth. When these trees are growing within 100 feet of a line, you can look for trouble from roots sooner or later. Take a close look at figure 5-53 which shows tree roots penetrating a line.

One method for removing roots in a sewer is to apply copper sulfate (blue vitriol). Another method is to use cable drawn scrappers; these may be homemade or equipment as shown in figure 5-50. Try copper sulfate first since this is the most economical.

When a sewer is completely stopped up, it is useless to apply copper sulfate. A partially blocked line that is flowing from 5 to 10 gallons per minute only

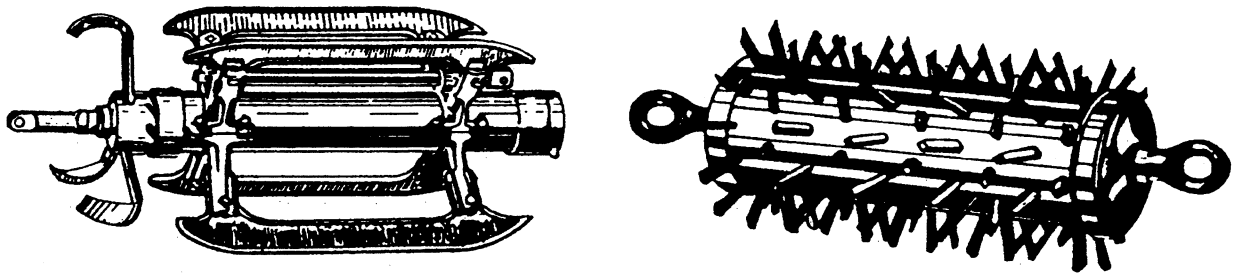


Figure 5-52.—Turbine-driven tools.

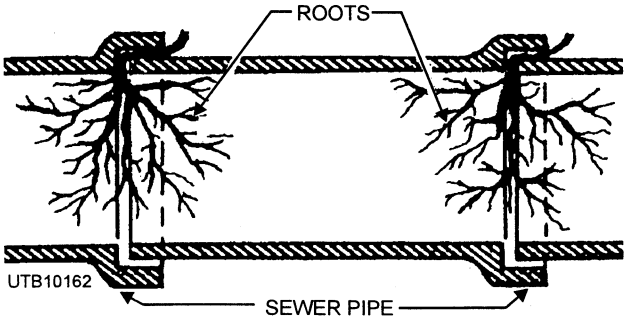


Figure 5-53.-Roots growing into sewer pipe.

requires a handful of copper sulfate crystals. If the flow is greater than 10 gallons per minute, apply more copper sulfate or treat the line with repeated applications. If the chemical fails to remove the roots, use power-driven equipment.

REPAIRING

Sewer breaks and obstructions must be repaired at once. Sewers under roadways, crushed by settling, must be encased in concrete or sleeved with steel piping. In difficult situations get technical assistance from higher authority.

Bypassing the sewage flow is usually required during repairs. The usual method is by blocking the upper manhole outlet with sand bags or an expandable rubber test plug, using portable pumps to discharge the sewage to a lower manhole through a fire hose or a temporary pipeline.

Excavations over 5 feet must be shored and ladders provided under safety requirements for excavation, building, and construction. Adequate guards and warning signs must be placed around the excavations in roadways. Details on the requirements mentioned are found in EM 385-1-1, *Safety and Health Requirements Manual.*

Q20. What is the first step to correct a problem in a sewer line?

Q21. You should use what size fire hose to do most sewer flushing jobs?

Q22. Accumulated sand and grit deposits should be removed at what point in the sewer system?

CLEARING STOPPAGES IN FIXTURES

LEARNING OBJECTIVE: *Recognize different types of equipment and methods for clearing fixture stoppages.*

Stoppages in fixtures are usually caused by materials lodged in the drain, trap, or waste line. Obstructions often can be removed by manually operated devices, chemicals, or both.

The method depends upon the seriousness and nature of the stoppage. The obstruction should be entirely removed and not merely moved from one place to another in the line. After the stoppage has been relieved, pour boiling water into the fixture to ensure complete clearance. Some of the methods used in clearing stoppages in fixtures are explained below.

When using a snake or sewer tape, keep track of the length of tape in the pipe, so you can determine the break or stoppage location. Also, with plastic pipe, exercise care not to use sharp ends to-avoid cutting through the wall of a pipe or fitting.

The FORCE CUP, or the PLUMBER'S FRIEND, is commonly used for clearing stoppages in service sinks, lavatories, bathtubs, and water closets. One type of force cup has a round, rubber suction cup, about 5 inches in diameter, fastened to a wooden handle, as shown in view A, figure 5-54. When using the force cup, partly fill the fixture with water. Now, place the force cup over the drain opening and work the handle

up and down to provide alternate compression and suction. Take care not to raise the cup off of the drain opening. The downward pressure or upward suction often clears the stoppage.

Another type of force cup, shaped to fit the opening of a water closet drain, works more efficiently than the round type in clearing stoppages in water closets.

The CLOSET AUGER and PLUMBER'S SNAKE are used for opening clogged water closet traps, drains, and long sections of waste lines (views B, and C, fig. 5-54). The closet auger is a cane-shaped tube with a coiled spring or "snake" inside and has a handle for rotating the coiled hook on the end of the snake. To insert the closet auger into the trap of the water closet, retract the coiled spring all the way up into the cane line curve of the closet auger. Hook the cane end, with its projecting hook, into the trap. Then start turning the handle to rotate the coiled spring as it is pushed down into the trap of the water closet. Rotate the handle continuously until the snake reaches the obstruction in the drain. Turn the handle slowly until the obstruction is caught on the coiled hook of the closet auger. Continue rotating the handle and pull back at the same time to bring the obstruction up into the water closet where you can remove it.

NEVER assume that the water closet is clear after one object is brought up and removed. Insert the snake of the closet auger again and repeat the procedure until the closet auger passes down into the closet bend and branch. Withdraw the closet auger. Put four or five pieces of toilet paper in the water closet and flush them through the fixture to make sure that it is completely open.

TRAP AND DRAIN AUGERS, such as the one shown in view D of figure 5-54, are used in clearing obstructions in traps and waste pipes. Trap and drain augers, also known as SINK SNAKES, are made of coiled, tempered wire in various lengths and diameters. They are very flexible and easily follow bends in traps and waste lines when pushed into them. In clearing stoppages from lavatories, service sinks, and bathtubs, first use a plumber's force cup. If the obstruction is in the trap and is not cleared by the action of the plunger, clear the trap by inserting a wire or snake through the cleanout plug at the bottom of the trap. If the trap is not fitted with such a plug, remove the trap. Protect the finish of the packing nut with

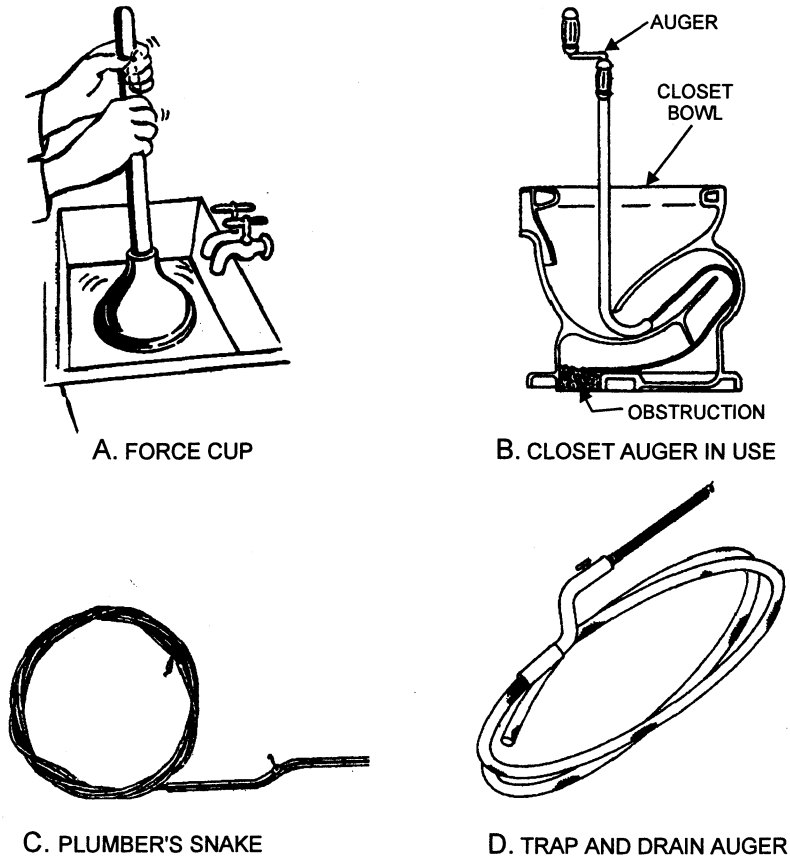


Figure 5-54.—Tools for clearing stoppages in plumbing fixtures.

adhesive tape or wrap a cloth around the jaws of the wrench.

Do not use a heavy steel-spring coil snake to clear traps under lavatories, sinks, or bathtubs. Use a flexible wire or spring snake that easily follows the bends in the trap. For example, a spring snake is used for clearing stoppages in floor drains. Remove the strainer or grate and work through the drain, or insert the snake through the cleanout plug opening nearest the obstruction. Stoppage clearance tools should be used with caution.

One reason why safety is so important is that a caustic chemical may have been poured into the stopped-up fixture in an effort to clear it. Caustic agents can cause serious injury if splashed into your face by a force cup. These caustic agents can also burn your hands while using a sink snake. When manually operated devices fail to clear stoppages, there are several types of chemicals that can be used to dissolve or burn them out. These chemicals are discussed briefly below.

CAUSTIC POTASH (POTASSIUM HYDROXIDE)

Stoppages can be burned out by pouring a strong solution of this chemical and hot water into the line through the fixture opening. Pour the mixture slowly into the pipe through a funnel. Since this solution can cause serious bums, personnel must wear goggles and rubber gloves. Potassium hydroxide (caustic potash) damages glazed earthenware, porcelain, and porcelain-enameled surfaces.

CAUSTIC SODA (SODIUM HYDROXIDE)

Kitchen and scullery sink stoppages are often tough problems because of grease, oil, or fat washed down along with coffee grounds and small bits of garbage into the drain. Grease congeals and acts as a binder for solid particles and can usually be cleared by successive applications of a chemical cleaner. Effective cleaners include caustic soda (sodium hydroxide) with bauxite (an aluminum compound or ore) and other ingredients to intensify their action or sodium hydroxide mixed with sodium nitrate and aluminum turnings. Adding water creates ammonia gas, which helps change grease to soap. This gas causes boiling and heating and helps dissolve the grease. When clearing a partially blocked drain, drop a small quantity of cleaner (from 2 to 8 ounces) into the open drain and follow with scalding hot water. Such cleaning agents cannot be satisfactorily used when the drain is completely plugged, since some flow is required to loosen the chemicals. A completely blocked drain must first be partially cleared with a plumber's snake before you can use the chemical cleaner effectively.

Q23. The seriousness and the nature of a stoppage determines the -type of equipment to be used. True or false?

Q24. You can use potassium hydroxide to remove a clog in PVC pipe. True or false?

SAFETY

LEARNING OBJECTIVE: *Identify procedures for safe work methods during handling, installation, and repairs of plumbing systems.*

As a Utilitiesman, treat safety as part of your job. Some of the main safety precautions in plumbing are given below. This training manual does not cover all you need to know about safety. Learn all you can about safety through further study and on-the-job experience.

PIPE WORK

When acids are used in working on piping, see that they are kept in only glass or lead containers. Keep out from under hot joints while they are being poured. Ensure that hot lead is not poured over water or wet caulking.

When floors are oily and cannot be kept dry, they should be covered with sand or an oil-absorbent compound. Any type of tee, valve, or other service connection used on piping maintenance or repair should be carefully checked to make sure it is designed to withstand maximum pressure.

SEWER WORK

Before beginning plumbing work on sewer jobs, pits, or tanks that require personnel to enter a confined space, the space must be inspected by a person qualified for Confined Space Entry. Environmental or Fire Department personnel normally conduct these inspections. They will check for toxic gases, explosive atmospheres, and oxygen deficient atmospheres. After

the space has been inspected and evaluated, you should take the following two steps:

1. Ensure that that personnel doing the work are confined space qualified. Ensure that proper respiratory equipment, safety belts, lifelines, and blowers are on hand.

2. Ensure monitoring equipment is in place and personnel are properly protected prior to entry of personnel into these spaces.

Where such hazards exist, the area must be controlled, and workers must wear proper respiratory equipment before entering the structure. Workers must be qualified to enter the space and receive instruction on the type of respiratory equipment for use in an emergency, and how to assemble and use this equipment properly.

At least two people should be assigned to each sewer job where there may be a hazard of broken or leaking pipes. One person should always be in a relatively safe position and be prepared to help in an emergency. To help dissipate toxic or flammable gas in a sewer or underground sewage pumping plant, remove the manhole cover several minutes before a worker descends. (See EM 385-1-1, *Safety and Health Requirements Manual,* and the *Occupational Safety and Health Administration (OSHA) Regulations,* 29 CFR 1910, for more information.)

CLOTHING AND EQUIPMENT

Wear goggles, gloves, and other protective clothing in all pipe-fitting, pipe-handling, and plumbing work, particularly when you are handling hot metal or acid or flying material could injure your eyes. When using compressed air to clean out sand, dirt, or scale from pipes before installation, you should wear goggles.

Wear flameproof garments when using blow torches, welding torches, or similar tools. Plumbers should wear heavy coveralls and leggings that cover the in step to protect against hot lead; if unavailable, the regular working uniform may be acceptable.

When entering deep tanks, deep sewers, and other deep underground structures, you should wear a safety belt and a lifeline.

Use portable blowers for tank, pit, or manhole work where you suspect noxious gases, vapors, or a lack of oxygen. These blowers should have vapor-proof, totally enclosed motors or non-sparking gas engines. Place the blowers at least 6 feet away from the opening and on the leeward side protected from wind, so they do not ignite flammable gas.

TOOLS

The following precautions apply to tools in general. Since pipe wrenches are one of the plumber's most important tools, precautions for these tools are in the following section.

Keep tools and appliances in good condition. Replace worn tools. Check hammer handles frequently; do not use hammers with broken or cracked handles. Also, do not let tools or materials clutter up the floor and become stumbling hazards. Pick up pieces of scrap pipe promptly and dump them in the scrap bin or scrap tubs for the next pickup.

Vise jaws should be used to grip material securely. When threads are being cut and during backing off operations, hold the stock firmly. Protect freshly cut threads with caps or couplings whenever possible. Guard against sharp burrs or fins. When operating a pipe-threading machine, determine the clearance of the pipe before starting the machine.

You should NEVER drop a cold ladle or other cold material into a pot of molten lead. It will explode.

PIPE WRENCHES

Never use an extension on a pipe wrench. The wrench was not made to handle this strain. Be sure there is plenty of clearance if the wrench should slip. Ensure that an adjustable pipe wrench faces forward in the direction the handle is to turn. When you use it in that way, an adjustable wrench can withstand the greatest force, because the pulling force is applied to the stationary jaw side of the handle. Also, an adjustable wrench should always bite near the middle of the jaws, because there are teeth in front if the wrench slips. Do not overwork small wrenches, avoid side strain, and never use them as hammers.

PIPE HANDLING

Workers should wear leather or leather-faced gloves when handling pipe. They should also stand to one side when pipe is being unloaded from a truck. Pipe should be piled so the ends are even and do not project into walkways. Pipe should be stacked straight; that is, not crossed.

Pipe should not be piled directly on the bare ground; racks or dunnage should be provided.

Pipe should always be blocked to prevent it from rolling. Where practical, store pipe on specially designed racks.

When lifting heavy pieces of pipe, bend your knees, keep your back line as vertical as possible, and hold the load close to your body; straighten your knees and pull the load up directly over your feet. Lift with your legs, not with your back. Pipe should be carried with the forward end up to clear the heads of other people nearby. When pipe is transported on a vehicle, a red warning flag should be placed on the projecting ends.

When the crew is carrying a long and heavy pipe, each member should try to work as a team while observing the following precautions:

1. Each member of the crew should understand the signals for lifting and lowering.

2. Members should ensure that their feet are in the clear.

3. When needing to use either tongs or a carrying bar with a U-shape bend to fit the pipe. When the crew is carrying a length of pipe at shoulder or waist level, each member should carry it on the same side.

4. Take a firm grip on the lifting bar or tongs.

5. Lift the pipe when the supervisor or co-worker gives the signal. All members of the crew should lift and move together.

6. Carry the pipe without sudden starts or stops; move slowly and place your feet firmly.

7. Stop at the appointed place and wait for the supervisor's or co-worker's signal to lower the pipe.

8. Lower the pipe carefully, bending at the knees as in lifting, and lower slowly along with the other members of your crew.

Use caution in handling THREADED pipe. The threads are always sharp and cut flesh easily. Do NOT put your hands inside a pipe.

When removing pipe, work from the top end of the pile as much as possible. Pipe larger than 2 inches in diameter should be handled by means of a hardwood pipe stick. Use block and tackle, chain falls, or other lifting devices where appropriate, when handling heavy pipes and fittings.

EXCAVATIONS

Maintenance operations on distribution systems may often involve excavation. Some precautions in making excavations are as follows:

- Wear a protective hat when working in a trench.
- Keep a safe distance from other workers to avoid striking them with tools.
- Do not jump into a trench: but sit on the shoulder and slide in if the trench is shallow. Use ladders where required; for example, a trench that is 5 feet or more in depth. Before climbing out of a trench, look in all directions for traffic danger.
- Remove earth and other material to avoid overhanging banks. Do not go under an overhanging bank and, when working near one, exercise caution. To remove an overhanging bank, work from one side to the center, always facing the point of danger. Where necessary, shore trench walls.
- When undercutting, provide adequate bracing and restrict the public from braced areas.
- Where practical, place excavated material at least 2 feet away from the edge of the excavation; otherwise, provide bracing.
- Keep tools, working material, and loose objects away from the shoulder of the trench.

Q25. What must you do before going down into a manhole?

Q24. When threading or cutting pipe, you should always wear what personal protective equipment?

GAUGES

LEARNING OBJECTIVE: *Identify types of gauges and methods for adjusting, testing, and repairing gauges.*

Gauges are delicate instruments and require care and attention. They are most important in the safe operation of boilers, air-conditioning and refrigeration systems, or compressed-air systems; they tell you what you need to know about water, heat, and pressure conditions, and eliminate guesswork.

Proper care of gauges should include the following:

1. Keep the dials and face clean.

2. Have the gauges well lighted to make the correct reading easier to take.

3. Keep the covers tight, and replace broken glass promptly.

4. Protect the gauges as far as possible from vibration, excessive temperatures, corrosive liquids, and rapid changes in pressure.

TESTING

Whenever you believe that a gauge is not accurate, test it with a deadweight tester. Figure 5-55 shows such a tester. In this testing device, the gauge under test is subjected to pressure by applying weights to a plunger. The plunger is accurately fitted into a vertical cylinder that contains a water-base hydraulic fluid.

> **WARNING**
>
> Mineral oil or other petroleum products must **NEVER** be used in the deadweight pressure gauge tester.

Weights are applied to the plunger, and the pressure is transmitted to the fluid and then to the gauge by way of transmission piping and a control valve. The plunger itself exerts a known pressure of approximately 5 psi. Additional weights are provided in sizes that exert pressures equal to 5, 10, and 20 psi.

In figure 5-55, notice that there are two horizontal cylinders and a main vertical cylinder. The plunger in cylinder A pumps hydraulic fluid into the instrument when it is first filled. The plunger in cylinder B exerts enough force on the fluid so the testing plunger maintains the weight platform in position about 2 inches above the top of the vertical cylinder. At the beginning of the test, the plunger in cylinder B should be screwed out as far as it will go, so cylinder B (as well as the main cylinder) fills with fluid. If the weighted test plunger is pushed too far down at anytime during the test, the plunger in cylinder B should be screwed in as far as necessary to force the test plunger up so it will have freedom of movement.

To test a pressure gauge in the deadweight tester, connect the gauge to the apparatus and fill the tester with the proper water-base hydraulic fluid, if necessary. (Some testers of this type are designed to be kept full of fluid at all times, but others require filling before each use.) Then level the tester. Apply weights to the testing plunger, as required, and check the pressure gauge readings for accuracy. The plunger should be gently rotated, as each weight is added, to ensure its freedom of movement. If the gauge reading increases by the proper amount as each weight is added

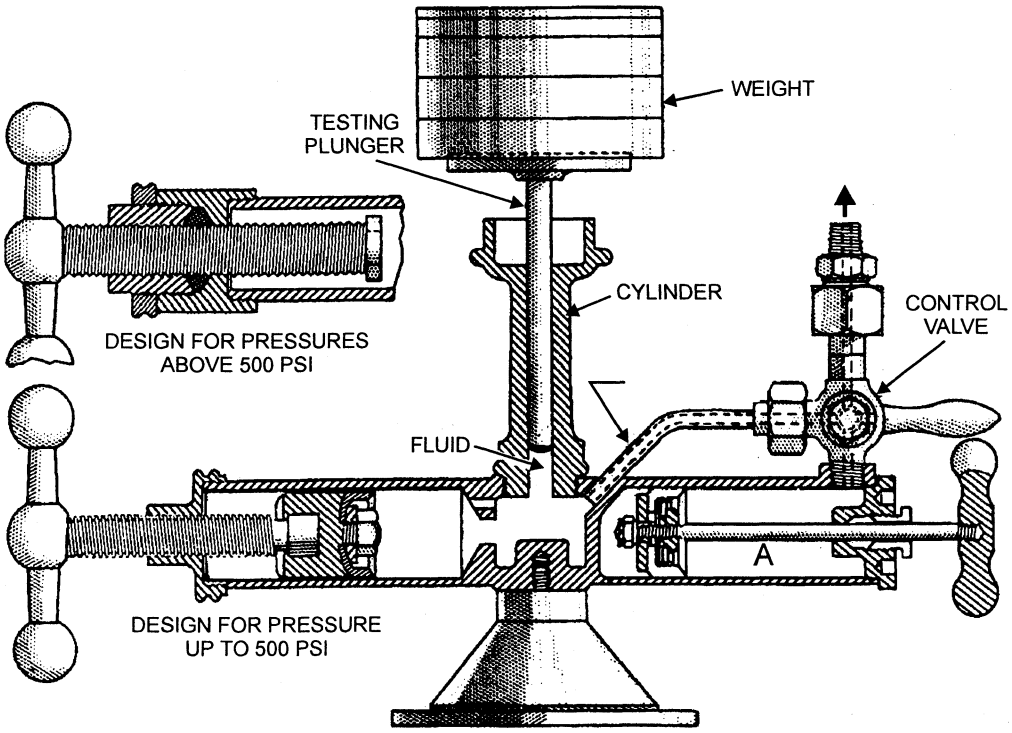


Figure 5-55.—Deadweight pressure gauge testing apparatus.

and if the gauge reading is equal to the pressure represented by the total weight added, the gauge is accurate. If the gauge is not accurate, it must be adjusted to read correctly.

ADJUSTING

When a Bourdon-tube pressure gauge is inaccurate, the following adjustments should be made:

1. If the pointer travels too far or not far enough as each weight is applied, change the ratio of movement between the Bourdon tube and the pointer. The movement of the sector gear meshes with a pinion on the pointer spindle. Lengthening the distance between the spindle and the link connection to the sector gear reduces the amount of travel to the pointer. Shortening this distance increases the amount of travel.

2. If the amount of travel is correct as each weight is added but the total reading is wrong, the pointer must be reset. Gauges of recent design have a countersunk split-head screw in the dial for setting the pointer. On some older types of gauges, the pointer must be pulled and reset. Pointer pullers are supplied with the gauge-testing apparatus.

3. If the gauge cannot be made to read correctly over the entire scale, it should be adjusted so the reading is correct at the working pressure. A table or curve should then be made that shows the corrections required for other readings.

From time to time, you may be required to adjust the diaphragm type of air pressure gauge, as shown in figure 5-56. The zero adjustment on these gauges should be checked frequently. Each gauge of this type has a three-way cock that can be turned to shut off the gauge without disconnecting the gauge piping. When the handle of the three-way cock is at right angles to the valve body, the gauge unit is open to the outside air pressure, and the reading on the scale should be zero. When the handle of the cock is parallel to the valve body, the gauge is open to the pressure in the line. A zero adjusting screw is provided either below the gauge or on one side of the gauge. Turn this screw in or out to bring the pointer to zero while the handle of the three-way cock is at right angles to the valve body. After making this zero adjustment, restore the gauge to service by turning the cock handle so it is again parallel with the valve body.

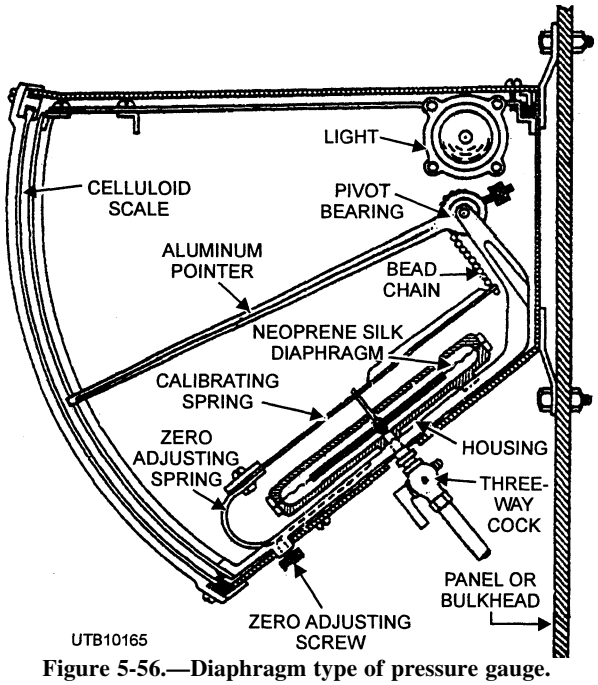


Figure 5-56.—Diaphragm type of pressure gauge.

REPAIRING

If you are required to replace any part of a pressure gauge, handle the mechanism carefully so none of the elements are bent or distorted.

You may occasionally have to replace the diaphragm in a diaphragm type of air pressure gauge (fig. 5-56). First, disconnect the pressure line below the unit. Remove the outside zero adjustment screw and the three-way cock (with its coupling), and remove the unit from its case.

Disassemble the unit by compressing the small spring on top of the calibrating spring to loosen the retaining pin. Remove the stem that holds the calibrating spring, and remove the screws (usually 10) around the edge of the diaphragm housing. The oil diaphragm can then be lifted out.

Clean both surfaces of the housing. Apply a small amount of gasket cement to the edge of the lower housing, and immediately place the new diaphragm-gasket assembly over the edge of the lower housing. Replace the top housing. Tighten the screws, being careful to draw them up uniformly. Replace the calibrating spring stem, compress the spring, and insert the retaining pin in the stem. Then replace the unit in the case. The gauge is ready for service.

Q27. On a deadweight tester, what is used to apply pressure to the gauge for testing?

Q28. What type of gauge has a zero adjusting screw?